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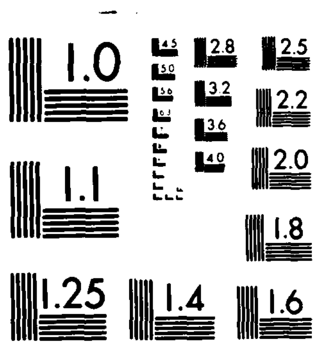

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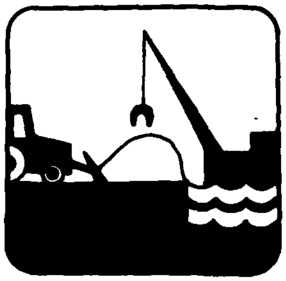
GREAT I
STUDY OF THE UPPER MISSISSIPPI RIVER

TECHNICAL APPENDIXES

VOLUME 3



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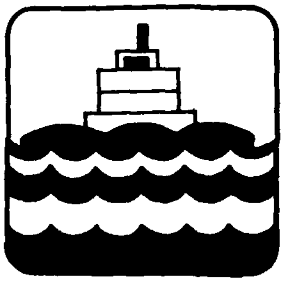

COMMERCIAL TRANSPORTATION

The GREAT River

1980

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Volume three is divided into two parts. Part A describes the operating capabilities of dredging operations; hydraulic dredging, mechanical dreging and clamshell dredging.

Part B describes present and future problems and needs of commercial river transportation on the Upper Mississippi River from Minneapolis/St Paul, Minnesota to Guttenberg, Iowa.

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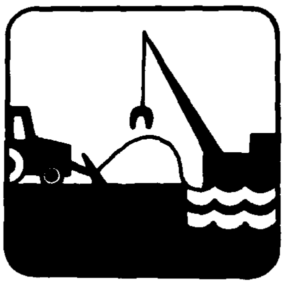
OUTLINE

GREAT I

SEPTEMBER 1980

VOLUME 1	MAIN REPORT	
	TECHNICAL APPENDIXES	
VOLUME 2	A.	FLOODPLAIN MANAGEMENT
	B.	DREDGED MATERIAL USES
	C.	DREDGING REQUIREMENTS
VOLUME 3	D.	MATERIAL AND EQUIPMENT NEEDS
	E.	COMMERCIAL TRANSPORTATION
VOLUME 4	F.	WATER QUALITY
	G.	SEDIMENT AND EROSION
VOLUME 5	H.	FISH AND WILDLIFE
VOLUME 6	I.	RECREATION
VOLUME 7	J.	PUBLIC PARTICIPATION
	K.	PLAN FORMULATION
VOLUME 8	L.	CHANNEL MAINTENANCE
		PART I - NARRATIVE
		PART II - POOL PLANS AND SITE DESCRIPTIONS - MINNESOTA RIVER, ST. CROIX RIVER, ST. ANTHONY FALLS, AND POOLS 1 AND 2
		PART III - POOL PLANS AND SITE DESCRIPTIONS - POOLS 3 AND 4
		PART IV - POOL PLANS AND SITE DESCRIPTIONS - POOLS 5, 5A, 6, AND 7
		PART V - POOL PLANS AND SITE DESCRIPTIONS - POOLS 8, 9, AND 10
VOLUME 9	M.	ENVIRONMENTAL IMPACT STATEMENT



MATERIAL & EQUIPMENT NEEDS

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT)

TABLE OF CONTENTS (CONT)

TABLES

FIGURES

ATTACHMENTS

MATERIAL AND EQUIPMENT NEEDS WORK GROUP

INTRODUCTION

The word "dredging" carries negative connotations for many people. It comes from the verb dredge, which means to drag up or clear earth as from a channel, making it deeper or wider. The earth that is removed is called "spoil" - another word with negative connotations. These connotations attached to the words illustrate the semantic problem facing readers of the Great River Study documents. It is natural for anyone to interpret what he reads on the basis of his own conceptions. Unfortunately, many people conceive of dredging as digging up silt, mud, gunk, and trash from a river bottom and dropping it on shore, "spoiling" the shore for everyone.

To illustrate this problem of interpretation, consider a sandbar on the river - clean, white sand formed into an inviting beach ringed with young willows and shrubs. This sandbar was made from spoil dredged from the bottom of the river. In reality, all but a very few of the many beaches along the Upper Mississippi River are produced directly from dredging.

Using the word "material" instead of "spoil" helps by implying (correctly) that the dredged sand is a useful substance. But the most difficult concept to portray is the need for the clearing of the channel - dredging - in the first place. The Mississippi River is one of the largest waterways in the world. Vessels of many sizes ply the waters of this mighty river bringing the world market closer to the agricultural regions of the Upper Midwest.

The river does not always cooperate in this very necessary function. In response to the weather and other natural forces, the river throws sand and shoals in the way of passing vessels. The sand and shoals must be cleared - dredged - and the sand - spoil - disposed of.

BACKGROUND

Congress has directed the Corps of Engineers to maintain the 9-foot navigation project on the Upper Mississippi River. This project was established by creating a series of pools behind dams with locks. In the slack-water pools behind these dams, sediments accumulate from natural movement of solids along the main channel, deposition from numerous tributaries, and redeposition of previously dredged material. These sediments must be periodically removed to keep the navigation channel open.

Historically, in this portion of the Upper Mississippi River, dredged material has been placed in shallow areas adjacent to the main channel or on natural islands. In some cases, placement has adversely affected valuable acreages of productive fish and wildlife habitat. According to the findings of the Environmental Impact Statement for Operation and Maintenance of the Upper Mississippi River 9-Foot Navigation Channel, the Government-owned plant and equipment are limited in their ability to place dredged material in areas and by methods that are compatible with total resource management. Consequently, a Material and Equipment Needs Work Group was established within GREAT and charged with suggesting new or additional equipment or new ways of using existing equipment to reduce the adverse impacts of channel maintenance activities.

This main challenge to the work group is joined by another of equal importance. This second challenge is to develop equipment needs and cost estimates for implementation of the recommendations of the other work groups.

WORK GROUP PARTICIPANTS AND COORDINATION

Knowledge of dredging equipment and techniques is peculiar to only two groups in the United States - the Corps of Engineers and the dredging industry. Resource management agencies, such as most of the Corps partners in the GREAT study, have little need for large-scale dredging expertise. As a result, active membership on the work group was sparse at best. The States and other Federal agencies by and large preferred to provide input and monitor the work group on a chair-to-chair level and through the Plan Formulation Work Group.

It was not that these other agencies had a lack of interest. The converse is more the case as evidenced by the support given to the dredging equipment seminar (A Better Way of Doing Business - Dredging: The Challenge, the Technology, the Opportunity) described later in this appendix and in Attachment 1.

SCOPE OF THE STUDY TASK

The charge given to the MENWG (Material and Equipment Needs Work Group) basically stems from one of the study objectives adopted by the Upper Mississippi River Basin Commission and the GREAT study partnership team in October 1974. This objective is to:

> "Assure necessary capability to maintain the total river resources on the Upper Mississippi River in an environmentally sound manner."

The Material and Equipment Needs Work Group was formed to achieve a major portion of this objective. To accomplish this, work group activities fall into three areas:

1. Determining the available dredging capability in public and private ownership.

2. Suggesting which types of equipment are best suited and cost effective for implementing a recommended channel maintenance plan.

3. Suggesting which types of equipment and techniques are best suited for implementing the recommendations of the other work groups.

Early in the study, a plan of action was developed to guide the work group's actions. The steps adopted at that time were to:

1. Research historical dredging operations to list available options.

2. Inventory all available dredging related equipment operated by the Government or private industry.

3. Determine equipment needs and costs for potential alternatives in dredging requirements developed by the Dredging Requirements Work Group and alternative placement sites developed by the Plan Formulation Work Group.

4. Coordinate with other work groups to determine equipment needs for the recommendations of those work groups.

5. Prepare recommendations for future equipment needs to accomplish GREAT study objectives.

6. Draft the Material and Equipment Needs Work Group Appendix.

ACTIVE CONDUCT OF STUDY

Recommendations involving equipment cannot be developed until a material placement plan is relatively fixed. Equipment to implement this selected plan can then be recommended. However, the approaches used in selecting placement sites depend on what equipment is available to do the dredging.

Early in the study, several types of dredges, both traditional and exotic, were reviewed to get a rough idea of how they might be used. The MENWG, along with the other work groups, concluded that five "methods" would be considered during plan formulation:

1. A 20-inch hydraulic cutterhead dredge (the William A. Thompson).

2. A 12-inch hydraulic cutterhead dredge (the Dubuque).

3. An 8-inch auger-hydraulic dredge (a Mudcat).

4. A pneumatic-displacement dredge (the Pneuma pump developed by SIRSI, Inc.).

5. A barge-mounted clamshell dredge (the Hauser).

Major factors in selecting these five methods were the production rates and operational characteristics information available.

From presentations made at the dredging seminar, field observations of some newer dredges, and meetings of the Channel Maintenance Task Force (see the Plan Formulation Work Group Appendix), the MENWG and the Plan Formulation Work Group concluded that other dredges should be considered. The Mudcat was dropped for main channel dredging because of its lower production rate. Horsepower requirements and fuel consumption rates coupled with lower production rates also eliminated the Pneuma pump. A bucket-ladder dredge and barge-mounted backhoe were added after cost information was available (see the Channel Maintenance Appendix).

Costs were determined for bucket-chain and hydraulic backhoe dredges with a production rate of about 70 percent of that of the Dredge Thompson. This size dredge was selected because:

1. The Thompson is included in the Corps Minimum Fleet Requirements (see section on Public Law 95-269) and will be available for emergencies at sites such as Reads Landing, Crats Island, and above Brownsville, Minnesota.

2. It seems compatible with fleeting, loading, and maneuvering barges.

3. The best information available on bucket-chain dredges pertains to this size.

Except for the bucket-chain dredge, published cost information is available for all the equipment types considered by the MENWG. The MENWG estimated the cost of building such a dredge and used that value in preparing dredging cost estimates (see Attachment 3).

Working from a familiarity with these methods, the Plan Formulation Work Group developed a set of selected material placement sites. In the closing stages of the study effort, the MENWG prepared cost data for implementing the recommended channel maintenance plan as documented in the Channel Maintenance Appendix.

During the study, close coordination was maintained with two other work groups - Dredging Requirements and Dredged Material Uses. These work groups more than any others affected the approaches taken by the MENWG.

DREDGING EQUIPMENT SEMINAR

As the MENWG began in-depth investigation of new and innovative dredges and dredging techniques, it became apparent that the most efficient way to gather the needed information on the state-of-the-art in dredge design and new techniques was to invite knowledgeable individuals to address GREAT on problems typical to this study area. It also became apparent that others in the study area could benefit from this first-hand contact. The idea of a seminar at which these people would present their information to GREAT, the work groups, and others grew into first a request to the GREAT I team and finally to the Upper Mississippi River Basin Commission for help in staging a major workshop-seminar on river dredging.

H. Ronald Kreh, in comments made at the Dredging Equipment Seminar (see Attachment 1), made the following points which very clearly describe the approach taken by the MENWG:

1. If you do not have a placement site, you cannot dredge.

2. If the dredging is to be done, the placement site must be acceptable to everybody.

3. Once you have picked a placement site, you can talk about dredge technology and dredging methods.

4. The placement site, whether it is on shore or in open water, and the distance from the dredge cut to the site determine the method of dredging.

5. The Corps will not be acquiring much new equipment. Under Public Law 95-269, the Corps will be getting out of the dredging business so any new dredging technology has to be attractive to contractors.

6. Dredge technology can only be a solution to a dredging problem if contractors are willing to invest money in a physical plant that can solve the problem.

The costs of dredging are often the key factors in selecting a placement site that is acceptable to everybody. In almost every case, costs must be estimated for various dredging methods to see if cost is actually a major consideration. Three levels of cost estimates were developed by the MENWG during the GREAT I study.

Preliminary level - Based on costs incurred by the Corps with its own equipment and calculated using Corps accounting procedures.

Plan formulation level - Based on published contractor rental rates and used to develop the channel maintenance plan.

Plan evaluation level - Based on estimating procedures developed by the Corps for preparing Government estimates of contracted dredging projects and used to evaluate the recommended channel maintenance plan.

The procedures are discussed in detail in Attachments 2 through 6.

At its quarterly meeting in August 1978, the Upper Mississippi River Basin Commission voted to jointly sponsor the seminar with GREAT. The Western Dredging Association (a subdivision of the World Dredging Association) also assisted in the seminar.

More than 250 people from across the country attended the seminar on 31 January and 1 February 1979 in St. Paul, Minnesota. The seminar and its findings are discussed in more detail later. The proceedings of the seminar are attached to this report (see Attachment 1).

WORK GROUP ACTIVITIES

From the start of GREAT I, a major share of the work group's activity was education oriented. First, the emphasis was on self-education for the members of the study intimately involved in developing a material placement plan and, later, education of those not closely related to the study but who are by necessity involved in dredging on the Mississippi River. The enactment of section 404(t) of the Water Pollution Control Act Amendments of 1965 (Public Law 92-500) brought several State regulatory agencies into direct contact with dredging.

The remainder of the work group's efforts concentrated on developing costs of dredging, not on a dollar per cubic yard basis, but on a very comprehensive, placement site-by-placement site and dredge cut-by-dredge cut basis. Without this level of detail, recommendations of a certain set of placement sites and methods of dredging would be very subjective.

The following is a simplified listing of specific actions taken by the work group:

1. An inventory of locally available equipment, both public and private, was developed.

2. Other Corps offices were canvassed for pilot projects and experimental techniques tried.

3. Drag beam agitation dredging tests done by Savannah District and shallow water bulldozer tests done by Seattle District were reviewed for possible application in the GREAT I area.

4. Several means of concentrating slurry discharges including sludge separators, vibrating screens, and hydrocyclones were reviewed.

5. Extensive reviews were conducted of tests of the Pneuma pump dredging system, especially tests conducted by the Waterways Experiment Station and Wilmington District.

6. Endless chain ladder-bucket dredges were investigated intensively. The study was not very broad-based because of time constraints. Domestic manufacturing firms with ties to European shipyards were major sources of information.

7. A seminar on dredging equipment especially suited to rivers was staged and incorporated into the GREAT study.

8. Detailed cost estimating procedures for several combinations of plant required for different dredging situations were developed.

9. The cost estimating procedures were used to estimate costs to dredge particular cuts and place the material at specific sites.

10. Investment costs for the specialized equipment needed to assemble a bucket-chain dredge were obtained. Preliminary estimates showed that it might be competitive, but no valid prices were available for manufacture in the United States.

11. Barge-mounted hydraulic backhoes were observed at small harbor clearing and large levee construction projects. The Mudcat dredge was used at two pilot projects - Fort Snelling, Minnesota, and Buffalo City, Wisconsin.

12. An accounting procedure was developed to document per hour and per day costs for different types and sizes of dredging plants.

13. Strategies for implementing the more significant resource management recommendations (for example, Weaver Bottoms island creation) were developed.

14. Strategies for placing material at particularly sensitive or extraordinary sites were developed (see Special Report and Special Project, page 69).

A summary of MENWG activities is given in the following table.

Material and Equipment Needs Work Group activity summary

Reference number	Activity name	How accomplished	Description	Remarks
1	Display list of available equipment types	By work group chairmen.	A list of all known equipment types available currently in public or private sector.	See attachments.
2	Canvass Corps offices for pilot projects, etc.	Correspondence with other offices.	Throughout the study, Corps offices were contacted for the latest information on techniques and equipment.	
3	Review of Pneuma pump dredge	By work group chairmen.	Review pilot project and test/case study documentation.	Little application to riverine dredging.
4	Review dewatering devices	By work group chairmen or members.	Prototypes were observed in operation on some devices. Conclusions reached on others based on literature were confirmed through correspondence with observers.	Little need in light of the approved channel maintenance plan.
5	Pneuma pump tests	By work group chairmen.	Observation of field test and review of WES findings.	Not suitable for channel maintenance because of high fuel and horsepower requirements, extreme noise levels, and low productivity.
6	Bucket-chain dredge investigations	By work group with significant input from Twin City Shipyard, Inc; DWE Gmbh (West Germany); and other Corps offices.	Review of production blueprints and published literature, conversations with operators and designers, and preliminary in-house designs and cost estimates.	Appears suitable for riverine dredging; may have noise problems (OSHA restrictions). Twin City Shipyard may soon be building one for U.S. dredging firm.
7	Dredging equipment seminar	Work group chairman with UMRBC and Western Dredging Association staff.	A 2-day seminar on types of dredging situations on the Upper Mississippi River and several types of dredges to fit those situations.	See Attachment 1.
8	Dredging cost procedures	Work group chairmen.	A computer program for estimating dredging costs for individual cuts and placement sites.	Done in three stages described in Attachments 2-5.
9	Site-specific dredging cost estimates	MENWG and Plan Formulation Work Group.	Using the cost estimating program, costs were prepared for each cust and placement site in the selected channel maintenance plan.	See Channel Maintenance Appendix.
10	Bucket-chain investment costs.	Work group chairmen.	Shipbuilding cost estimate.	See Attachment 3.
11	Backhoe and Mudcat pilot projects	Work group chairman and Fish and Wildlife Work Group chairman.	Observation and "hands-on" trials of the equipment.	
12	Accounting procedure	Work group chairmen.	Document the per-hour cost rates for the cost-estimating programs.	See Attachment 6.
13	Resource management recommendation strategies.	Work group chairman and Plan Formulation Work Group members.	Suggestions on how to physically implement some of the more significant GREAT recommendations dealing with specific sites in the study area.	See Channel Maintenance Appendix.
14	Material placement strategies	Work group chairman and Plan Formulation Work Group members.	Suggestions on how to physically implement some of the more vexing material placement problems in the channel maintenance plan.	See Channel Maintenance Appendix.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

In recent years, dredges have acquired a reputation as environmental villains, earned or not. A dredge is, however, just a machine - a tool. To condemn all dredges is similar to declaring all knives lethal weapons. Just as a knife in the hands of a skilled surgeon is a very useful and beneficial tool, a dredge in the hands of a skilled and knowledgeable dredger can become a very useful tool for both channel maintenance and environmental benefit.

While it is not important for most of the people involved in GREAT to have a high level of knowledge about a particular dredge's operating characteristics, it is important that they have knowledge of the capabilities of different dredges. By this knowledge, we do not simply mean that they know the Dredge William A. Thompson can move 1,000 cubic yards of material per hour or can move it up to 10,000 feet with the Boosterbarge Mullen. What we mean is that they know that, for mechanical dredging methods, the distance the material is to be moved is much less significant than the manner in which the material is handled at the placement site. And for a hydraulic dredge to operate efficiently, it must be able to bury the cutterhead into the face of the cut (at a depth 1 1/2 times the pipe diameter). Also, clamshell dredges have lower production rates in shallow cut areas because the bucket cannot be filled on each cycle. This type of information is shown on the following tables reprinted from the May 1974 Journal of the Waterways, Harbors and Coastal Engineering Division of the American Society of Civil Engineers, "Development and Future of Dredging," by Adolph W. Mohr.

Mechanical Dredges

Dredge type	Dragline on barge	Dipper dredge	Clamshell or orange peel bucket dredge	Endless chain bucket dredge
Dredging principle	Scrapes off material by pulling single bucket over it toward stationary crane. Lifts bucket and deposits dredged material in a conveyance or on a bank.	Breaks off material by forcing cutting edge of single shovel into it while dredge is stationary. Lifts shovel and deposits dredged material in a conveyance or on a bank.	Removes material by forcing opposing bucket edges into it while dredge is stationary. Lifts bucket and deposits dredged material in a conveyance or on a bank.	Removes material by forcing single cutting edge of successive buckets into material while dredge is slowly moved between anchors. Lifts buckets and deposits dredged material in a barge or own hopper.
Horizontal working force on dredge	Medium intermittent force toward bucket.	High very intermittent force away from bucket.	No forces.	Medium constant force away from bucket.
Anchoring while working	Dragline crane can be on shore or on barge. If on barge, latter can be secured with spuds or anchors.	Several heavy spuds.	Several spuds or anchors.	Several anchors.
Effect of swells and waves	Can work up to moderate swells and waves.	Very sensitive to swells and waves.	Can work up to moderate swells and waves.	Very sensitive to swells and waves.
Material transport	Transport occurs in barges, trucks, or cars. Crane does not transport material. Material disposal occurs in many ways.	Transport occurs in barges, trucks, or cars; dredge does not transport material. Material disposal occurs in many ways.	Transport occurs in barges, trucks, or cars; dredge does not transport material. Material disposal occurs in many ways.	Transport normally occurs in barges. Dredges equipped with hoppers are limited to material disposal by bottom dumping.
Dredged material density	Approaches in-place density in mud and silt. Approaches dry density in coarser material.	Approaches in-place density in mud and silt. Approaches dry density in coarser material.	Approaches in-place density in mud and silt. Approaches dry density in coarser material.	Approaches in-place density in mud and silt. Approaches dry density in coarser material.
Comments	The term "dredge" is questionable for this machine, since it is not exclusively built for underwater excavation and is frequently used for material removal above water. It is suitable for all but the hardest material and has a low production for its size.	Special hard material dredge of simple principle. Rudimentary machine can be assembled for temporary service by placing power shovel on spud barge. Low production for size of plant and investment.	This machine is simple in principle. It can be assembled in rudimentary form for temporary service by placing a crane on a barge. It is suitable for all but the hardest materials and has a low production for its size.	Highly developed machine. Not used in United States (other than as part of mining plant) but used extensively in other countries. It is suitable for all but the hardest materials and has a high production for its size.

Dredge type	Hydraulic dredges: Cutterhead dredge	Dustpan dredge	Hopper dredge	Sidecasting dredge
Dredging principle	Material is removed with a rotary cutter (or plain suction inlet in light material) picked up with dilution water by the suction pipe, and transported through the pump and the discharge line. While working, dredge swings around spud toward an anchor.	Material is removed with water jets, picked up by a wide but shallow suction opening and transported through the pump and the discharge line. While working, dredge is slowly pulled toward two anchored spuds or anchors.	Material is removed and picked up together with dilution water by draghead sliding over bottom (or stationary) and flows through suction piping, pump, and discharge piping into hoppers of vessel.	Material is removed and picked up together with dilution water by draghead sliding over bottom and flows through suction piping, pump, and discharge arm over side of vessel back into the water.
Horizontal working force on dredge	Medium intermittent force opposing swing to side.	Medium constant force opposing forward movement.	Slight constant force opposing forward movement.	Slight constant force opposing forward movement.
Anchoring while working	Two spuds and two swing anchors (one working spud and one walking spud).	Two spuds or anchors secured upstream while working.	Dredge moves under own power to dig a channel or is anchored to dig a hole.	Dredge moves under own power to dig a channel.
Effect of swells and waves	Very sensitive to swells and waves.	Very sensitive to swells and waves.	Little affected by swells and waves.	Little affected by swells and waves.
Material transport	Transport occurs in pipeline. Length of discharge line depends on available power, but can be extended with booster pump units to a total length of several miles.	Transport occurs in pontoon supported pipeline to side of dredge. Spoil discharges into water. Booster pump units are not used with this plant.	After material is in hoppers, transport is over any suitable waterway. Material can be bottom dumped or pumped out (if so equipped). Pump-out is similar to pipeline dredge operation.	Transport occurs in pipeline on discharge boom over side of dredge. Material discharges into adjacent water.
Dredged material density	Diluted to an average of 1,200 g/l.	Diluted to an average of 1,200 g/l.	Diluted to an average of 1,200 g/l.	Diluted to an average of 1,200 g/l.
Comments	Highly developed machine with intricate horizontal moving procedure used throughout the world. Suitable for all but very hard materials. High production for size of plant.	Special sand dredge used only in United States in Mississippi River. Floating line is positioned with rudder in discharge stream. High production for size of plant.	Highly developed machine used throughout the world. Suitable for all but very hard materials. Production depends on traveling time to dump and mode of discharge.	Special sand dredge. Sand transport is limited to length of discharge boom. Used in coastal inlets or where material discharge into water is not objectionable. High production for size of plant.

EXISTING EQUIPMENT AND DREDGING PRACTICES

Dredging has been used to clear waterways for thousands of years. Most of the world's major ports would not exist without the assistance of hydraulic dredges. The first recorded hydraulic pump was built in 1836, and a successful suction dredge was built in England in 1861. The Suez Canal was excavated by as many as 60 hydraulic dredges that removed 97 million cubic yards over a 10-year construction period. The Panama Canal was started by the French group that worked on the Suez. They dredged from 1862 to 1889 without success. The U.S. Army Corps of Engineers tackled this project in 1902 and completed it in 1914 using both hydraulic and mechanical dredges. The present canal is maintained by a rock drilling plant, 15-cubic-yard dipper dredge, and a 28-inch cutter-suction dredge. These three pieces of equipment annually move the same amount of dredged material as the St. Paul District has historically moved with the Dredge William A. Thompson.

Navigation problems on the Upper Mississippi River were recognized as early as 1824 when the Federal Government authorized removal of snags, shoals, and sandbars; excavation of rock in several reaches of rapids; and closing off of meandering sloughs and backwaters to confine flows to the main channel and thus ensure more adequate depths for navigation in times of low water. The first comprehensive improvement of the river for navigation was authorized by the River and Harbor Act of 18 June 1878. A 4½-foot channel from the mouth of the Missouri River to St. Paul was established. This channel was maintained with bank revetments, wing dams, longitudinal dikes, and dams at the headwaters of the Mississippi River to impound water for low-flow augmentation. In 1890, the 4½-foot channel was extended to Minneapolis, Minnesota, requiring removal of boulders and dredging of bars. In 1907, a 6-foot channel was established in response to the River and Harbor Act of 2 March 1907.

The additional depth was obtained primarily by construction of rock and brush wing dams, low structures extending radially from shore into the river for varying distances to constrict low-water flows. The 6-foot channel was further improved by construction of locks and dam 2, completed in 1930.

In 1930, Congress authorized the 9-foot channel navigation project on the Upper Mississippi River between the mouth of the Missouri River and Minneapolis. The authorizing legislation (River and Harbor Act of 3 July 1930) provided for a navigation channel of 9-foot depth to be achieved by constructing a system of locks and dams supplemented by dredging.

EXISTING EQUIPMENT

Dredges can be classified into two distinct types - mechanical and hydraulic. (See tables on pages 13 and 14.) Many different combinations have been devised to meet varying conditions. The mechanical dredges lift bottom sediments out of the water by means of bucket devices attached to chains, cables, or levers. Hydraulic dredges use a moving stream of water to make a slurry of the material to be moved.

Channel maintenance in the study area is normally accomplished with the Dredge William A. Thompson, a 20-inch hydraulic cutterhead dredge, and the Derrickbarge Hauser, a 4-cubic-yard deck-mounted crane. Early in the study, most of the dredging contractors in the area were contacted to determine what equipment they had available. Extensive checking was done with other Corps of Engineers Districts in an effort to locate equipment or methods that could be applied to the unique problems present in this section of the Mississippi River.

During the GREAT study, two major additions were made to the St. Paul District channel maintenance floating plant. The first was a 20-inch booster dredge, the Boosterbarge Mullen, which has been added to the Dredge Thompson fleet. The 12-inch hydraulic dredge Dubuque was acquired for use, with modifications, on smaller channel maintenance dredging sites and to be paired with a clamshell operation to unload barges.

Hydraulic Dredges (Cutterhead)

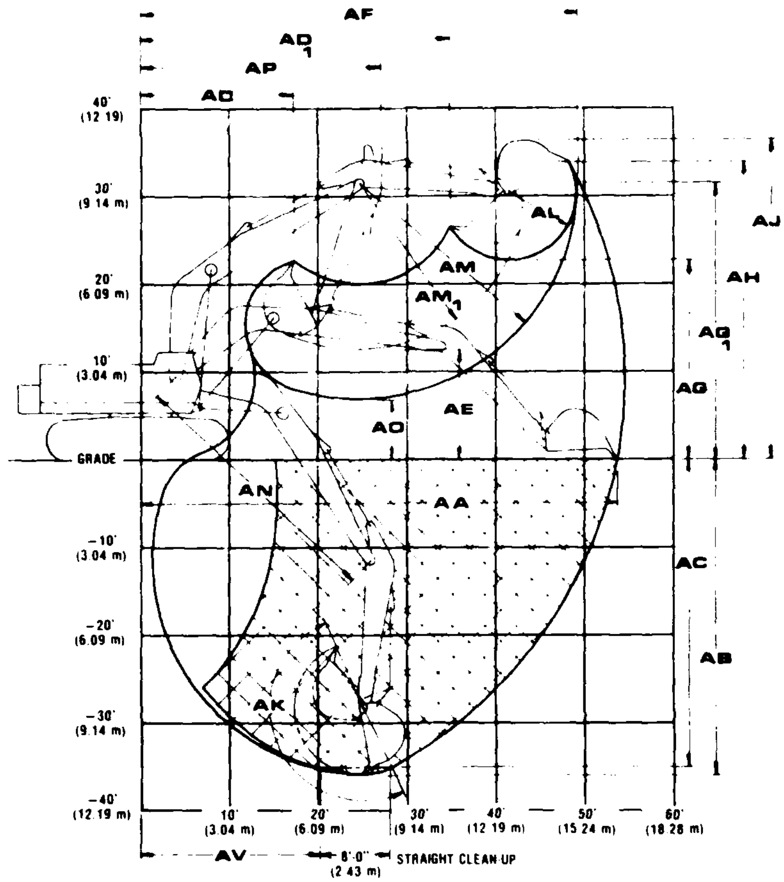
The basic principle of hydraulic dredging is described in the table on page 14. Cutterhead dredges are anchored in the dredge cut with two spuds at the stern. Lateral movement of the dredge is controlled by hauling winches near the bow which are connected by cable to remote anchors. Pulling on these hauling winches rotates the dredge about one spud. Working in combination, the spuds and hauling winches give the dredge the ability to swing from one side of the cut to the other as it "walks" into the face of the cut.

Mechanical Dredges (Backhoe)

A backhoe is a commonly used excavator. It is most often used in trench construction where versatility, accurate control of the digging operation, and maneuverability are important. Available sizes range from small units mounted on the 3-point hitch of a farm tractor and used for trenching drain tile or underground cable (digging depth of about 6 feet with a 10-foot reach) to machines capable of loading large dump trucks with a single bucketful.

The backhoe is usually mounted on a tracked undercarriage and turntable. A boom arm extends from the body of the machine, and a dipper arm is hinged from the end of the boom. The dipper arm extends from the end of the boom into the cut. A bucket on the end of the dipper arm does the digging and excavating. It is hinged to swing through approximately 170°. During the digging operation, the dipper arm is extended and the boom lowered into the cut. The bucket is filled as it is drawn across the excavation toward the machine. When the bucket is filled, it is rotated upward toward the machine and lifted from the cut. The following figure shows the range and typical dimensions of a large hydraulic backhoe.

HOE ATTACHMENT WITH TRACTOR LOWER



NOTE: CROSS HATCHED AREA INDICATES STRAIGHT CLEAN-UP RANGE

			(metres)
AA	Maximum reach at grade level	53'-5"	(16.29)
AB	Maximum digging depth (tip of teeth)	35'-7.5"	(10.87)
AC	*Maximum depth of cut for 8' level bottom (straight clean-up)*	35'-0"	(10.67)
AD	Radius of dipper teeth at maximum boom elevation — dipper arm & dipper swung fully in	17'-4.5"	(5.3)
AD_1	*Radius of dipper teeth at maximum boom elevation* — dipper arm fully extended, dipper swung fully in	35'-1"	(10.7)
AE	Minimum vertical clearance of bottom of dipper from grade at maximum bottom elevation	12'-9"	(3.89)
AF	*Maximum clearance radius of dipper teeth at maximum boom elevation*	48'-10.5"	(14.9)
AG	Minimum vertical clearance of dipper teeth from grade with attachment at maximum height	23'-1"	(7.04)
AG_1	*Vertical clearance of dipper teeth relative to dimension AF*	31'-5"	(9.59)

			(metres)
AH	Dipper teeth distance from grade at end of highest dump	33'-11"	(10.35)
AJ	Maximum height of attachment	36'-1.5"	(11.0)
AK	Dipper sweep angle	176°	
AL	Dipper sweep radius	7'-5"	(2.26)
AM	*Dipper arm sweep radius over teeth extend*	24'-3"	(7.39)
AM_1	Dipper arm sweep radius — retracted	18'-8"	(5.70)
AN	Boom length from boom foot pin to boom point pin	30'-4"	(9.25)
AO	Vertical clearance for highest dumping sweep of dipper teeth	7'-2"	(2.19)
AP	Maximum attachment radius with boom at maximum elevation and dipper arm and dipper swung fully in	27'-6"	(8.38)
AV	*Minimum radius of 8' level bottom at maximum depth*	20'-0"	(6.10)

As a general rule, backhoes operate most efficiently when swinging horizontally through 60° from digging to dumping. Increasing the swing from 60° to 90° decreases productivity by about 14 percent for most equipment on the market today. For most operations, the operators would position any barges alongside the dredge spud barge centered on the pivot point of the backhoe. The average swing would then be 90°. Because of the geometry of the spud barge and limits that it would place on the angle of excavation, all dredging would occur within 30° (in each direction) from the center line of the dredge.

In essentially every operating mode, the backhoe would be positioned to work off the end of the spud barge. If this end is considered the bow, we would expect a minimum of two spuds to be placed on the stern. For reasons explained later, these two spuds would be no farther apart than the difference between the backhoe's longest and shortest limits of digging for the depth that it will be digging (below the deck).

In a dredging operation, a backhoe has the unique ability to propel itself through the cut using the boom and dipper arm without any outside power source or positioning cables and anchors. If there is little current in the area to be dredged, the movement can be easily done by the operator with almost no loss of effective dredging time. When a move is necessary, the operator tucks the bucket close to the machine and anchors it into the river bottom. Both spuds are then raised and the dipper arm extended keeping the bucket anchored in the river bottom, thus moving the spud barge back. The spuds are lowered, anchoring the barge, and the dredge is immediately ready to resume dredging, perhaps without even removing the bucket from the river bottom. Depending on how fast the spuds can be raised and lowered, an experienced operator should be able to perform this maneuver in the time it takes for one to two cycles (anywhere from 30 seconds to 2 minutes).

If there is some current in the cut area or if the transport barges tied alongside would pull the dredge off line, a second procedure, keeping one spud anchored at all times, would probably be used. The operator again tucks the bucket close to the machine anchoring it in the river bottom. The port spud is raised, the backhoe is swung to the right 30° as the dipper arm is extended pivoting the dredge on the starboard spud. Without moving the bucket, the port spud is lowered and the starboard spud raised. Again, without moving the bucket from its anchorage, the backhoe is swung to the left through 60° as the dipper arm is extended further pivoting the dredge on the port spud. The spuds are once again lowered and raised, and the backhoe returned to center as the dipper arm is extended. The dredge is now parallel to its initial position farther along the cut the distance between the port and starboard spuds. Again, depending on how fast the spuds can be raised and lowered, this maneuver should take no more than three to six cycles (3 to 4 minutes).

This procedure may not be the most productive for larger cuts or cuts where large areas are to be dredged with shallower cut faces. It is more suited to cuts where the cut faces are deeper, and it is more advantageous to limit the width of the dredging cut to less than 60 feet. If the swings of the backhoe are limited to 30° on either side of the dredge center line, the effective excavation width is limited to approximately one-half the maximum digging reach of the backhoe arm at the depth being dredged. If the swing can somehow be extended to 60° on either side of the center line, this width can be doubled.

Where channel geometry and other factors allow, another dredging maneuver may be more productive. A maneuver cycle would begin with the dredge at a 60° angle to the center line of the cut. For this discussion, the dredge is assumed to be angled to the left. As all the excavating within reach of the backhoe is completed, the bucket is anchored in the river bottom near the right-hand limit, one spud is raised (e.g., the port spud) and the backhoe swung from right to left moving the barge somewhat closer to the center line of the cut. The amount of this swing should be determined by the operator depending on his skill, judgment, and geometry of the spud barge. The spud is lowered and excavating continued until the dredge has moved from 60° left of center line to 60° right of center line. The other spud (starboard) is then raised, and, by whatever means the operator chooses, the dredge is returned to 60° left of the center line of the cut. If the two spuds are as far apart as the difference between the backhoe's longest and shortest digging limits, the dredge will have advanced through the cut by that distance and will be ready to begin another pass.

The time needed to step the dredge through each pass should be no more than one digging cycle depending on how fast the spuds can be raised and lowered. The time needed to return the dredge depends on what means the operator chooses. The simplest method is to walk it back using the arm of the backhoe to pivot the dredge around one spud. If a tender is standing by, it may be faster to have it push the dredge back to its starting position. Swing anchors and cables should not be used unless it is known before the job starts that no loading would occur off the port side (in this example, it would interfere with the docking and loading of transport barges).

The operator has an option of digging on the return pass. For the first part, the only excavation would be near the backhoe, and a full-width excavation would not develop until near the end of the pass. Trial and error in the field would determine if this would be a wise maneuver.

With a wide sweep operation such as this, a prudent operator may try to keep transport barges being loaded on the side of the dredge toward which he is moving, effectively cutting his average swing angle from 90° or more to about 75° and increasing his productivity from 86 percent of a 60° swing angle production to 93 percent of a 60° swing angle production rate for most machines. This can only be done on a continuous basis if the draft of loaded transport barges does not exceed available water depth in the undredged cut area.

<u>Production Rates</u>. - Production rates for various backhoe units operating in different materials are readily available from manufacturers. One leading manufacturer has published the following data for two of its backhoes digging from grade level to a maximum 20-foot depth, 60° swing to load trucks parked at grade level, and effectively operating 50 minutes per hour.

Approximate hourly production rates (cubic yards per hour)

Item Backhoe specifications	750-horsepower backhoe				375-horsepower backhoe			
Bucket capacity, PCSA heaped (cubic yards)	4.5	5.5	6.25	9 (1)	2	3	4	5
Bucket duty rating	E.H.D.	H.D.	M.D.	L.D.	E.H.D.	H.D.	M.D.	L.D.
Material types								
Common excavation	340	430	505	-	140	220	320	-
Sand and gravel	440	550	650	875	190	300	445	530
Common earth	400	495	585	790	180	275	400	480
Moist loam, sandy clay	460	575	675	910	210	320	465	555
Clay, hard dense	380	470	555	-	155	245	365	-
Clay, wet sticky	325	400	475	-	130	210	-	-
Rock, well blasted	360	450	-	-	145	235	-	-
Rock, poorly blasted	280	350	-	-	105	180	-	-

(1) Estimated.

This same manufacturer also publishes four factors which can be used to more closely estimate the production rate that can be expected on a particular job. These factors are shown on the following four tables.

Job efficiency factor (1)

Job efficiency	Working minutes per hour	Job efficiency (percent of 60 minutes)	Factor
Excellent	55	92	1.10
Average	50	83	1.00
Below average	45	75	0.90
Unfavorable	40	67	0.81

(1) Factors are the same for all backhoe units.

Depth of cut factor

Maximum depth (feet)	Average depth (feet)	Factor 750-horsepower backhoe	Factor 375-horsepower backhoe
10	5	1.15	0.97
15	7.5	1.00	1.15
20	10	0.95	1.00
25	12.5	0.85	0.95
30	15	0.75	0.85
35	17.5	0.65	0.75

Angle of swing factor

Swing in degrees	Factor
45	1.05
60	1.00
75	0.93
90	0.86
120	0.76
180	0.61

Material loadability factor(1)

Bucket loading	Factor
Easy digging	0.90 - 1.00
Medium digging	0.80 - 0.90
Medium-hard digging	0.65 - 0.75
Hard digging	0.40 - 0.65

(1) To adjust for variations in bucket heaping.

To estimate the productivity on a job, this manufacturer suggests that the approximate hourly production rate for the type of material and bucket size being considered be multiplied by each of the factors for the job to determine what production rate can be reasonably expected.

The Material and Equipment Needs Work Group knew of a contractor using a machine very similar to the 375-horsepower example shown throughout this appendix. This contractor is using this machine with a 4-cubic-yard bucket and is getting approximately 250 cubic yards per hour production. This backhoe is sitting idle approximately 20 minutes per hour waiting for barges, is digging an average of 15 feet deep (below deck), is swinging through an average of 90° to load barges, and has medium to easy digging. Working backward through the factors and capacity chart with these data, it can be assumed that the material being dredged acts similarly to moist loam and sandy clay.

HISTORIC PRACTICES

Before 1937, St. Paul District had no dredges to maintain the navigation channel on the Upper Mississippi River. Initial construction and maintenance were accomplished by Rock Island District. As early as 1871, Rock Island dredges and snagboats were used to clear sandbars, pull debris, and construct wing dams in the St. Paul District. These efforts provided a 3½-foot navigation channel.

From 1878-1906, Congress authorized funds to clear the channel by dredging, closing bypasses, and building lateral canals. These authorizations resulted in the 4½-foot channel project which was directed by Rock Island District.

In 1907, Congress directed the Corps to maintain a 6-foot channel. Over $52 million was spent on channel improvements which included improved dredging and continued wing dam construction. Locks and dam 2 at Hastings, Minnesota, was completed in 1930 as part of the 6-foot channel project.

In 1930, Congress authorized the 9-foot channel. This project was an economic boost during the Depression.[1] Commercial transportation on the river was diminishing in response to the introduction of the steel rail, and the water project was necessary to revive the river transportation system. Between 1930 and 1939, Corps activity concentrated on building the 29 locks and dams over 669 miles of the river.

In 1930, St. Paul District assumed responsibility for a portion of the river development. The major dredges included three hydraulic dredges (the Pelee, Vesuvius, and Cahaba) and a few others brought from other Districts. The District acquired the hydraulic dredge William A. Thompson and the mechanical dredge the Derrickbarge Hauser (formerly Derrickboat 767) in 1937. These two pieces of equipment have done most of the dredging in the District since the 1937 navigation season.

St. Paul District maintains a 9-foot channel on 242.5 miles of the Upper Mississippi River, 14.7 miles of the Minnesota River, 24.5 miles of the St. Croix River, and 1.4 miles of the Black River. In addition, its dredging plant performs maintenance dredging on 314 miles of the Mississippi River in Rock Island District.

POSSIBLE NEW EQUIPMENT TYPES AND RECENT DEVELOPMENTS

Because most of the dredging done in the United States is in harbors and coastal waters and developing and building new dredging plants is expensive, the Corps uses older, existing machines where possible (that is, where they can be adapted to meet the new demand) and designs new equipment for the coastal waters. In recent years, the innovative techniques and designs have come from Europe or Japan, but they are still only variations on the methods shown in the tables on pages 13 and 14.

One of the most exotic of the recent developments is the Pneuma pump dredging system developed by Dr. Giovanni Faldi of SIRSI (Italian Corporation for the Research of Water Use). The Pneuma pump is a solid displacement pump operated by compressed air, which acts as a piston. The Pneuma pump is described in detail on page 28.

(1) About 90 percent of the labor was from relief rolls.

New Developments in Hydraulic Dredging

Two innovations have been added to cutterhead hydraulic dredges that have increased their efficiency and added depth. One is mounting a centrifugal pump on the ladder near the cutterhead to increase the depth that can effectively be dredged. The other is a bucket wheel in place of the cutterhead which increases digging efficiency in harder materials. Neither of these has specific adaptation to Mississippi River dredging in the GREAT I area.

One of the success stories in recently developed Corps dredges is the Currituck. The Currituck is a self-propelled, split bottom barge to which drag heads and pumps have been added so that it functions as a small self-loading hopper dredge. Its primary purpose is to maintain navigable depths in shallow-draft inlets and use the material for beach nourishment by dumping material into the surf zone of nearby eroded beaches. In operation, dredging coarse sand from coastal inlets, it fills in 15 to 20 minutes (270 cubic yards) and, depending on length of haul, has a productivity of up to 1,000 cubic yards per hour. It nourishes beaches by nosing up on the beach as far as possible (7 1/2 feet of draft) and dumping the hopper (4 1/2 feet of draft unloaded). Wave action and propeller wash as the vessels backs away from the surf zone carry the sand onto the beach. There have been no major breakdowns and few minor ones. It operates with a crew of three. This operation has shown itself to be economically feasible and environmentally sound.

New Developments in Mechanical Dredging

One very old method of dredging has been used successfully in some areas. Slips and docks in Savannah Harbor have been cleared by dragging a 5-ton beam over the sandbar with a 4,000-horsepower harbor tug. The harbor tugs do this maintenance in their stand-by time. This method has also been used in some areas for channel maintenance with smaller beams and smaller tugs. In the particular case of Savannah Harbor, the material removed from the slip may be contributing to shoaling of the Federal navigation project.

Endless chain ladder-bucket dredges were first used in Europe in 1778. The first one was powered by two horses and could deliver 30 tons per hour. Ladder-bucket dredges grew in capacity and dependability and for the next 100 years were the workhorse dredges on European waterways.

The first hydraulic dredges were developed at the same time as the United States was getting into the dredging business. The General Moultrie was one of the first hydraulic dredges and was used by the Corps to dredge the port of Charleston. Because of this historical coincidence and the growth of hydraulic dredging technology over the next 60 years with a corresponding growth in dredging needs, the Corps and the American dredging industry developed little mechanical dredging capability. Europeans, with their experience with ladder-bucket dredges, knowledge of the capability of mechanical dredges, and different harbor and channel requirements, maintained and continued to develop mechanical dredges while developing their hydraulic dredging capability.

Technological developments such as new driving methods, measuring and control techniques, position fixing and communication devices, and, above all, scale enlargements kept bucket-chain dredges in competition in Europe. The use of bucket-chain dredges in the western hemisphere has been limited to isolated mining operations. The energy crunch and environmental awareness of recent years has brought the bucket-chain dredge into the spotlight. Previous concerns for economy (least-cost) are gradually being replaced by concerns for efficiency (doing the most with the least). A bucket-chain dredge plant can move granular material with less horsepower and at higher densities than some other types of dredges.

Riverine Hydrology

Much interest has developed in recent years for letting the river dredge itself. Altering flow characteristics or modifying the flowage channel is one of the ways this can be accomplished. A more detailed discussion of this can be found in the Dredging Requirements Work Group Appendix and in Dr. D. B. Simons' presentation in Attachment 1.

The dredge design and manufacturing industry has made significant steps in recent years toward improving the operation and efficiency of its product. Three factors acting in concert have played a role in this progress: environmental concerns, energy efficiency, and unpredictable labor costs. How the new designs accommodate these factors will become apparent as we look at some of them individually.

Pneuma Pumping System

The Pneuma pump was developed by Dr. G. Faldi of SIRSI, Florence, Italy. It is a solid displacement pump with compressed air acting as a piston and as the driving force.

The standard pump body has three sheet steel cylinders with the diameter about equal to the height. At the bottom of each cylinder is an inlet pipe for the dredged material slurry; at the top is a pipe for compressed air, and a slurry outlet pipe. The outlet pipe is enlarged immediately above the cylinder to contain a spherical valve and seating of abrasive-resistant rubber. The steel outlet pipes from the three cylinders combine with a flange to which a flexible discharge pipe is bolted.

The pump operates on a two-stroke cycle of compressed air entering and displacing the slurry into the discharge pipe and fresh slurry entering while spent compressed air escapes to the atmosphere. As the compressed air enters the cylinder, the inlet valve remains closed and the outlet valve is opened by pressure sufficient to overcome the combined head of liquid depth, further height of pumping and friction. The compressed air supply is shut off at the bottom of its stroke (that is, when the cylinder is nearly empty) and the compressed air pipe is opened to the atmosphere causing the outlet valve to close. The external liquid pressure then opens the inlet valve and the slurry beneath it is forced into the cylinder, driving out the remaining air but being prevented from rising up the compressed air pipe by the floating valve which closes the opening. The cycle is then repeated.

It is the combination of the three cylinders which is significant. The compressed air supply and exhaust are regulated by a distributor which opens and closes passages to overlap the cycles of the three cylinders so that the discharge of the second cylinder begins when the first is completed continuing in turn to the third and then the first again. The discharge is therefore uniform and continuous. There are usually 1 to 3 cycles per minute. A similar result can be obtained from two cylinder pumps which are sometimes used for fixed installations.

The Wilmington District, Corps of Engineers, and the U.S. Army Waterways Experiment Station recently tested the Pneuma pump on the Cape Fear River and Masonboro Inlet (Wilmington, North Carolina). One portion of this test simulated conditions on the Upper Mississippi River.

The testing was conducted in two parts. The purpose of the first part was to find, measure, and document the performance of the Pneuma pump while the more basic variables were changed one at a time. The purpose of the second part was to establish the operational feasibility and economy of practical assignments.

The effects of type of bottom material, dredging depth, and speed over the bottom were tested while the Pneuma pump discharged into the Currituck.(1) An effort was made to keep this evaluation as scientific as practical, placing less emphasis on economic considerations. A Pneuma pump (model 600/100) was mounted on the Workboat Snell. The pump and connecting hoses were hung from a 15-ton telescoping cable crane and the distributor was mounted on the deck. Two 1,050-cubic-foot per minute (115-pound per square inch) compressors were on the deck. Only one was used in the shallow water (less than 15 feet), a situation similar to Mississippi River dredging.

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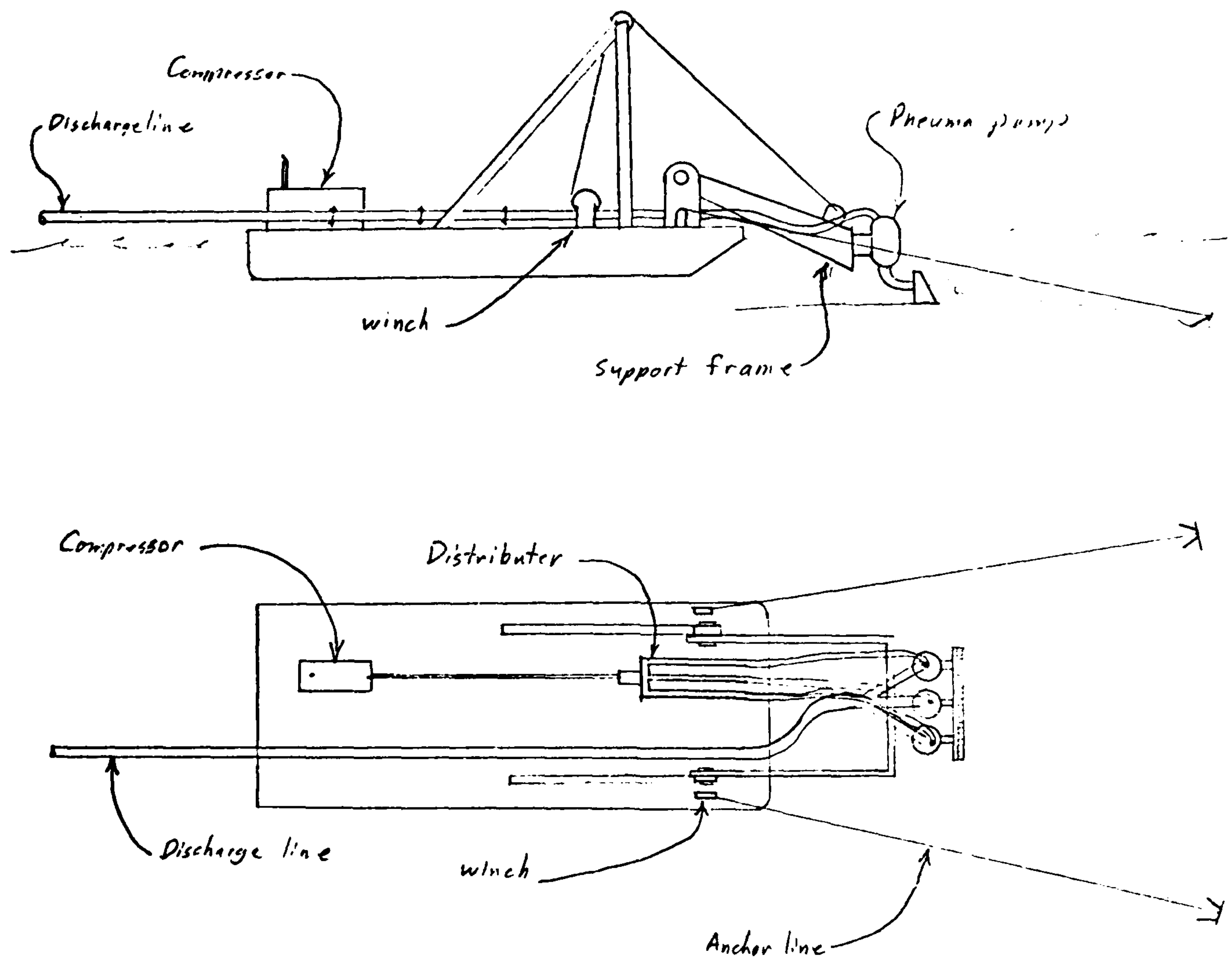
(1) The Currituck is a 300-cubic-yard self-propelled hopper dredge described on page 20.

Preliminary results of the test show that the Pneuma pump is adequate for specific applications. The high mass concentrations claimed for silty materials (1,250-1,350 grams per liter) seemed to be substantiated. It is probable that these concentrations were not reached in the sandy materials on the Cape Fear River because only inappropriate nozzles were available for testing at this site. The dozer blade type nozzle would appear to give better concentration and production rates. Additional tests using these nozzles would be advisable, but the MENWG suggests that further tests of this device for main channel maintenance dredging would not be justified for reasons explained later. The Pneuma pump may be suitable for some side channel, fish and wildlife management, and recreation purposes.

The Pneuma pump's use as a channel maintenance-production dredge seems inappropriate because of its high horsepower requirements and energy inefficiency. The best advantage of the Pneuma pump seems to be the extremely low resuspended bottom sediments (turbidity) that it produces. This makes it useful in highly polluted areas or where there have been spills of heavier-than-water pollutants.

The Pneuma pump could be adapted for use in the GREAT I area for these limited applications. One modification would be a barge equipped with a modified dredging ladder and power winches (see the following figure).

The test also raised questions about the discharge distance that the pump alone can reach. Data have been gathered but the results have not been compiled.


Compressor
Dischargeline
Pneuma pump
winch
Support frame
Compressor
Distributer
Discharge line
winch
Anchor line

Pneuma pump

Hopper Dredges

A hopper dredge is a self-contained, self-propelled vessel that hydraulically loads material into its hold with on-board pumps. It can move under its own power to a deposition site where, for shore placement, it can pump out with the same pumps used to load the hopper, or it can bottom dump the material through doors in the vessel's hull. The unique feature of most hopper dredges is their ability to load material while under way without use of spuds or anchors. This type of vessel is well suited to channels where pipeline dredges would present a navigational hazard and also in locations where deposition locations are not available within economic pumping distances. This type of dredge is not used to excavate very hard material. Hopper dredges range in size from 300 to 12,000 cubic yards

A hopper dredge with hydraulic self-unloading capability would be suitable for portions of the selected channel maintenance plan. This type of dredge could be used efficiently where shoaling rates are slow enough to allow a productivity rate of less than 300 cubic yards per hour, when overflowing of the hoppers is acceptable, and where hydraulic unloading of the hopper can be done. The Corps should not pursue this type of dredge for permanent use on the Upper Mississippi River, but may find it profitable to bid a hopper dredge on some of the maintenance dredging.

This type of dredge would have the advantage of smaller total plant investment and labor requirements while sacrificing some degree of productivity. For instance, the Currituck could be competitive on dredging at sites such as near Weaver Bottoms in pool 5 and placing material at the various side channel closings identified as site 5.30.

Clamshell Dredges

Atlas Clam Dredge, Inc., has an automated clamshell dredging device. The open dredging bucket is dropped at high speed through a digging well in the deck of a specially designed pontoon section barge. As the bucket passes through the digging well toward its highest point, an electro-mechanically activated chute is placed in position below the closed bucket. The bucket is opened and dredged material is dumped on the chute and diverted into a receiver. The dredge operates on about 50-second cycles and moves about 120 cubic yards per hour with 2- to 3-cubic yard buckets. It needs a crew of only two or three because the hoisting machinery and chute movements are automatic. Depth limit can easily be set and the movements included in automation setup.

Drag Beam Method of Agitation Dredging

Agitation dredging is perhaps the oldest known method of dredging for channel maintenance. Usually this method involves scarifying the material (if needed) and physically moving it by such methods as propeller wash or dragging.

Savannah District has used two types of dragging with some success. In the Savannah harbor, slips and docks have been cleared by dragging a 5-ton beam over the bottom with 4,000-horsepower harbor tugs. This method has been very effective and cost efficient. The tugs dredge while they are standing by between calls to their normal duty.

Savannah District has also cleared small shoals in its channel areas by dragging a 2-ton beam (14-inch H-pile) with a 600-horsepower tug. Both methods appear to be effective for small areas and where the material can be dragged to nearby deeper waters.

Direct Hydraulic Loading of Barges

During the GREAT I study, it was suggested that barges could be loaded directly by a hydraulic dredge. The rationale for this suggestion is that a hydraulic dredge can efficiently (at today's prices) remove sand from the channel bottom while a barge is the most efficient mover of dredged material over long distances. It was felt that significant cost savings could be realized. Several parties with experience in hydraulically loading barges were contacted. The most notable results of this survey are:

1. Cape Girardeau Sand Company, Cape Girardeau, Missouri, operates a 14-inch suction dredge about 50 miles above the Ohio River for mining river sand used in concrete. Most of the material is in the range of mortar sand and is similar to the Mississippi River material found in the St. Paul District. The pumped sand slurry is deposited directly into compartmented deck barges of 26 by 100 feet. These carry about 300 tons with a draw of 6 to 7 feet. The material is moved about 4 miles to a land area where it is removed by a deck-mounted crane. This mining operation has been used for 57 years.

2. Winter Brothers Sand, St. Louis, Missouri, mines sand from the Merrimac River. It pumps unclassified sand out of the river with a 16-inch hydraulic dredge and loads it directly onto compartmented deck barges sized 26 by 100 and 26 by 120 feet. These barges carry 300 and 500 tons, respectively. Holes in the side of the deck compartments allow overflow water to return to the river. The barge drafts are 6½ feet and it takes 35 minutes to fill a barge. The barges are moved approximately 20 miles downriver and unloaded into the classifying plant with a 4-cubic yard bucket.

3. Basic Material Company, St. Louis, Missouri, uses a 16-inch hydraulic dredge to load directly onto deck barges having 4-foot high cargo compartments. The barges are 26 by 100 feet, draft 6½ to 8 feet, and load in 15 minutes.

4. Bussen Quarries, St. Louis, Missouri, does the majority of the commercial dredging in the St. Louis area. It operates 16-, 14-, and 12-inch hydraulic dredges which pump directly onto deck barges. The company operates nine deck barges and has transported material as far as 20 miles.

In all these cases, the barges are loaded to overflow and the water (with some suspended solids) is allowed to overflow until a significant portion of the load is the coarser sediments which have settled out.

Hydraulic Unloading of Barges

The work group examined two hydraulic methods of unloading material from barges:

1. Bottom dumping the material at the suction head of a small dredge. The material would be resuspended in a slurry and pumped inland to the placement site.

2. Adding water to the barge to suspend the material in a slurry which can be removed by a centrifugal pump and moved to an inland placement site.

The first method seems more adaptable to the Upper Mississippi River because:

1. The complement of equipment is more flexible. The smaller hydraulic dredge would also be available for channel maintenance dredging.

2. Most of the material dredged in the area is suitable for rehandling in this manner.

3. The plant can easily be dismantled and moved to a new location in less than 2 days after a period of operation of probably less than 2 weeks and still be competitive. This operation is typical of dredging volumes and frequencies in this area.

Mechanical Unloading of Barges

The unloading of loaded barges by some type of mechanical device is as varied as any contractor's imagination. Basically, any type of earthmover or dry materials handling device can do the work. From what the work group has witnessed, the selection of one device over another is more a matter of personal choice or availability than one of careful investigation and analysis. Also, the cost effectiveness of several types seems comparable for the same range of productivity. Those operations which the work group felt worthy of further consideration were:

1. A crane or backhoe stationed at the placement site which would unload the barges and place the material onshore. Dozers, endloaders, bottom dump scrapers, trucks, or conveyors would distribute the material into the placement site.

2. Ramps on shore allowing endloaders to directly unload the deck barges with other equipment as needed.

All of these methods are in use at terminals or construction sites in the GREAT I study area.

"Wagger"

For use on smaller hydraulic dredges (up to 12 inches), a rigid truss replaces the first two pontoons of the discharge line. The truss is anchored by a set of spuds and is attached to the dredge body by a pivot. One set of hydraulic rams on the truss pivots the dredge through a full 180°. A second ram advances a telescoping portion of the truss through 20 feet without repositioning the spuds. This eliminates the need for swing anchors and cables and permits a wider swing.

Hydrocyclones

A hydrocyclone is a contained-force vortex. The less dense slurry is drawn from the center of the vortex and out the top of the device while the denser slurry is drawn out the bottom of the device at the funnel end of the vortex. Hydrocyclones have been suggested as a means to decrease the water content of a slurry from a hydraulic dredge or increase the density of a slurry to be handled in a placement site. Frequently, it is not efficient to transport the entire volume of water to a placement site, nor is it desirable to limit the turbidity of return flows from a diked placement area (if the area is too small or too full to allow settling).

Laboratory and field tests have been conducted. All of the tests have been plagued with a lack of consistency. Behavior and effects observed in small-scale models are not confirmed in larger-scale versions. Available test results show that:

1. On clay slurries with low solids content, the hydrocyclones perform well in clarifying the effluent and concentrating the slurry.

2. On most dredged materials, hydrocyclones perform from below expected to poor primarily because of the combination of high solids content, small particle size, and high viscosity.

3. The hydrocyclones are very successful at recovering sand from dredged material.

Therefore, hydrocyclones are poorly suited for use on the Upper Mississippi River. The areas in which they would perform best - where it is desirable to separate dredged sand from slurry - are where they are needed least. In these areas, the dredged material is known or suspected to be clean and unpolluted. Thus, no clarification or concentration is needed. Below Lake Pepin, the sand underlying the placement sites is significantly thicker than the sand layer above the lake. This layer allows the slurry water to percolate at a faster rate which further diminishes the need for a hydrocyclone.

In the areas where a hydrocyclone is most desirable, the dredged material is not conducive to efficient operation of the hydrocyclone. In lower pool 2 and upper pool 4, the bottom sediments have higher levels of pollutants, primarily organics and heavy metals that are bound to fine sediments. It would be desirable to separate the clear water from the sediments and return it to the river. Also, the percolation rate in these areas is slower than below Lake Pepin so the containment areas must be larger to attain the needed retention time. Concentration of the slurry would help reduce the size of the containment areas. However, hydrocyclones do not work well on the type of material found in these areas and their value is questionable.

The work group made a field investigation of a variation in hydrocyclones. This particular device was a mechanical settling tank with a filtered effluent. The only place this concept appears to have value as part of a dredging operation would be in highly polluted situations and with small hydraulic dredges. A major drawback which must be overcome for this device to become useful is a filter element. Studies by the Waterways Experiment Station for the Dredged Material Research Project (DMRP Manual - Treatment of Dredged Material) found that an element capable of removing suspended solids from large volumes of water has not been developed.

IMPLEMENTATION OF SELECTED PLAN

The selected material placement plan is a resource-oriented strategy for the placement of dredged material regardless of the type of machinery available. The Channel Maintenance Appendix describes these resources and what actions involving channel maintenance dredging are required to protect, enhance, or exploit these resources.

The trend in newer dredges has been toward lower manpower requirements for sustained production rates. The investment made in a piece of equipment remains fairly stable, but the wages of the operators and labor force will fluctuate. Therefore, automation in the dredging equipment and the smallest unit that can do the job are usually most desirable.

In many people's minds a necessary recommendation of the GREAT report should be to: (1) retain the William A. Thompson and modernize its plant to facilitate new techniques on the Upper Mississippi River, (2) dispose of the Thompson in favor of a fleet of smaller hydraulic and/or mechanical dredges, or (3) develop a dredge designed specifically for implementing the selected plan.

Recommendations of this type imply two assumptions that are not necessarily valid.

1. The values of society concerning our resources can be accurately predicted over the next 40 years. With this predictive capability, the equipment needs could be defined and a plant suitable for this region could be developed.

2. The Corps will be required to perform the channel dredging with its own equipment.

In the first case, the two basic dredging methods, hydraulic and mechanical, are not likely to dramatically change in the next 40 years, but the devices will undergo technological improvement which the Corps should take advantage of.

In the second case, the Industry Capability Program, designed to spur competition and constructive growth in the dredging industry, has been in operation for several years in one form or another and has been formalized in Public Law 95-269. The program allows privately owned dredges and Corps dredges to bid competitively on dredging jobs and will eventually relieve the Corps of much of the dredge ownership responsibility it now has. This bidding process, if fully extended into the GREAT I area, could allow the most efficient and effective dredge plant to do the dredging (presuming that the organization with the most efficient and effective plant would have a competitive advantage). By promoting competition, not only between the Corps and the industry but more importantly between dredging contractors, the latest available techniques and machinery capable of implementing GREAT's selected plan could be expected to do the dredging.

Although two dredging plants, the Thompson and Hauser, have been doing all the channel maintenance work on the Upper Mississippi River, they will not always be available to St. Paul District. Therefore, even without the requirements of Public Law 95-269, some dredging would have to be done by contract. Now that Public Law 95-269 is becoming effective, it appears that the chances for competition between dredging firms are improving. One of the main concerns of the MENWG during the study was that the only competition developing would be between the Corps and one or two local contractors and, as a result, little economy of operation would be realized.

The dredging cost estimates displayed in the Channel Maintenance Appendix show that a barge-mounted backhoe dredge could be very cost effective for much of the dredging on the Upper Mississippi River. This finding opens the market for dredging contracts to another large group of contractors - general, sewer and water, and highway contractors. The option appears attractive for a contractor who owns a suitable backhoe to temporarily mount it on a barge and use it as a dredge. Thus, competition between contractors would be stimulated.

Preparing contract documents for dredging on the Upper Mississippi River will always be a major problem. Shoals develop most often from high flows during spring runoff and from heavy summer rains in the tributary basins. The time span from the initial hydrologic event to the shoaling of the main channel does not permit the preparation of plans and specifications and a bidding procedure. The only procedures which seem viable are to negotiate a rental contract or a unit price plus retainer with a contractor for an entire season. Any special conditions would be negotiated as dredging is needed. Better forecasting techniques and a higher level of river engineering would significantly reduce the contracting problem (see the Dredging Requirements Work Group Appendix, particularly the portions on river hydraulics).

OTHER RIVER MANAGEMENT OBJECTIVES

Several of the other work groups have as objectives better management of the resources in the river valley. Some of the recommendations being developed call for some type of construction but not something that could easily be contracted. In these cases, the Material and Equipment Needs Work Group concluded that a plant owned by one of the management agencies and available to a resident manager for the agency to implement the recommendations appears to be practical. These smaller special plants could be:

1. A portable dredge plant for dredging in backwaters and off-channel areas for fish and wildlife management purposes.

2. A recreation enhancement plant which could move from site to site shaping, keeping down unwanted vegetation, planting areas where appropriate, etc., to make those sites best suited for recreation more attractive and possibly divert heavier recreation use from areas that could not support it.

PILOT PROGRAMS DURING GREAT

During the study, several pilot projects and studies were undertaken to gather data and test management actions. Whenever possible, more than one test or data gathering effort were combined in one pilot project. The work group benefited from these cooperative efforts.

SIDE CHANNEL OPENING PILOT STUDY AT BUFFALO CITY

During 1975, many requests for side channel openings in the reach of the river covered by the GREAT I Study were made. These requests were carefully considered by the Side Channel Work Group. The Buffalo City project was selected for demonstration. This project consisted of dredging an access channel to the city, moving the material approximately 7,000 feet, and placing it where Buffalo County could construct a combination road raise and floodwall.

The 8-inch hydraulic dredge used for this project was a rented unit named the "Mud Cat". The "Mud Cat" was being considered by the work group as having potential to perform dredging at the low-volume sites or where the dredging cut face is shallow. This dredge is small anough to be transported to the job site on a semitrailer. It propels itself along a 3/8-inch steel cable so it must be anchored at each end of the cut. It has a rotating 8-foot auger ahead of a pump; this auger moves material back into the pump inlet.

The discharge floating and land lines are not different from standard fixtures. Two auxiliary booster pumps (trailer-mounted) were used to transport the material up to 7,000 feet to the placement site. These pumps provided more than enough power.

The outfall system consisted of 80 feet of standard shore pipe with 2-inch holes on 1-foot centers along the lower side of the pipe. The pipe rested on oil drums placed under each joint. Most of the solids and about one-half the water dropped out through the holes with the remainder flowing out through the end of the line. The initial installation for filtering of solids consisted of a snow fence covered with burlap. This filter did not work so the dredged material was used to build a containment dike that formed a settling pond. The settling pond was approximately 575 feet by 25 feet, and had an outfall consisting of five 8-inch pipes through the berm and directly into the river. The pond proved to be very effective and trapped a significant amount of fines in the area. Buffalo County expected to use this material as topsoil for grassed areas.

The costs of operation were very favorable considering that this was a new operation. Some time was lost as a result of training, obtaining supplies, and correcting the problems of control of the return water.

The overall cost of dredging and transporting to the deposition area was computed at $2.14 per cubic yard. The cost of dredging only was estimated at $1.31 per cubic yard with the movement of the material to the beneficial use site cost at $0.83 per cubic yard. If a four-shift operation had been run, the estimated cost could have been reduced to $1.65 per cubic yard, on the basis of fewer days of rental of the machine. These costs include a Federal employee benefits charge of 33 percent and an additional District overhead of 14.4 percent. The benefits apply only to basic wages and not to overtime so the cost of overtime was not a significant consideration. (Costs are in 1975 dollars.) A summary of the costs of this operation is given in the following table.

Summary of costs for Buffalo City side channel opening

Item		Amount
Total costs		
Equipment rental		
$23,694.12 ÷ 60 days = $394.90/day		
$394.90/day X 37 days =		$14,611.30
Labor		
Regular	$6,225.12	
Overhead ($6,225.12 X 1/3)	2,075.04	
Overtime	3,510.24	
Total		11,810.40
Fuel, supplies, and miscellaneous		2,008.17
District overhead (0.144 X ($11,810.40 + $2,008.17))		1,989.87
Total		30,419.74
Assume 14,200 cubic yards of material dredged.		
Cost per cubic yard = $30,419.74 ÷ 14,200 cubic yards = $2.14/cubic yard		
Dredging costs only		
Equipment rental		
$16,865.12 ÷ 60 days = $281.08/day		
$281.08/day X 37 days =		10,399.96
Labor (Use 2/3 of hired labor)		
$7,340.50 ÷ 2/3 =	$4,893.67	
Overhead = $4,893.67 X 1/3 =	1,631.22	
Total		6,524.89
Fuel, supplies		672.12
District overhead (0.144 x ($6,524.89 + $672.12)		1,036.37
Total		18,633.34
Assume 14,200 cubic yards of dredged material.		
Cost per cubic yard = $18,633.34 ÷ 14,200 cubic yards = $1.31/cubic yard		
Estimated costs for four-shift operation		
Equipment rental		
$394.90/day X 16 days		$6,318.40
Labor		
$529.84/day X 16 days	$8,477.84	
Two Sundays, 1¼ time	264.92	
Supervision	1,073.29	
Benefits	3,151.87	
Total		12,967.92
Fuel, supplies, miscellaneous		2,008.17
District overhead (0.144 X ($12,967.92 + $2,008.17))		2,156.56
Total		23,451.05
Assume 14,200 cubic yards of dredged material.		
Cost per cubic yard = $23,451.05 ÷ 14,200 cubic yards = $1.65/cubic yard (23-percent savings)		

CHANNEL DIMENSIONS AND RELATED DREDGING

The only reliable recorded information on channel dimensions before 1956 is data on location, dates, and quantities of dredging. Data from 1943 indicate that 11 feet below low control pool was a common depth of dredging with the depth occasionally being 15 feet below low control pool. In 1945, the average depth was 13.7 feet. Directives issued for the 1946 season established 13 feet as the standard for normal 9-foot channel maintenance. No records on width of dredging were retained.

Since 1937, the Dredge William A. Thompson has done essentially all dredging in the GREAT I study area. The Thompson has been well suited to the 13-foot depth because dredging to this depth generally calls for a 3-foot dredging face. In terms of volumes dredged per unit of time, this dredging face is near the optimum for a 20-inch hydraulic dredge. Before GREAT, the use of the Thompson was considered sound judgment because it had the lowest cost per cubic yard of material dredged.

This work group questioned whether cost per cubic yard is a reasonable criterion for measuring the cost effectiveness of dredging operations. The taxpayers money spent on channel maintenance is not intended to buy the movement of sand from one place to another but to buy a channel large enough to allow navigation. Thus, the taxpayers' money is better spent if the Corps spends \$2 per cubic yard to move 25,000 cubic yards of sand (\$50,000) than \$1.50 per cubic yard to move 40,000 cubic yards (\$60,000) as long as the channel is maintained.

This argument also supports the finding of the Dredging Requirements Work Group that dredging volumes may be significantly reduced. These findings show that, in many cases, dredging to a shallower depth can reduce volumes significantly. At reduced depths, a 20-inch hydraulic dredge cannot move sand as efficiently and costs per cubic yard increase.

The volume of material to be removed at a dredge cut is determined by the depth and width of the cut. The volume often determines the environmental impacts and dredging costs. Studies quoted in the Dredging Requirements Work Group Appendix show that, generally speaking, as depth is decreased the width needed to maintain directional stability increases (but is seldom in a direct ratio). In addition, many site specific factors affect the relationship between depth and width.

Once the channel dimensions are established and a placement site is selected, the choice of dredging equipment is often intuitively obvious or at least the list of appropriate methods has been limited. However, the equipment that is available may influence the choice of placement site and perhaps even the dredging dimensions.

To help ensure that the best knowledge available is used to determine channel dimensions, hence dredging quantities and costs, the MENWG supports a "channel dimensions team" as suggested by the Dredging Requirements Work Group.

LEGAL FRAMEWORK AND CONSTRAINTS

MORATORIUM ON PURCHASE OF DREDGES AND DREDGING EQUIPMENT

Beginning in the mid- to late-1960's, controversy developed over Corps vs. private industry dredging. The dredging industry opposed the Corps plans to replace several older dredges and build several new dredges claiming the willingness and, if the work was offered, the ability to acquire the capability to do the work of the new dredges. The Corps took the position that its responsibilities could not be met without its own dredging fleet.

The House Committee on Appropriations stated in its "Report on the Corps of Engineers FY 1973 Budget Request" (House Report 92-1151):

> "The Committee has placed a moratorium on all proposed plans for replacement or modification of dredges which are not presently under contract, including hopper dredges, pending the comprehensive study of the national pipeline dredging requirements which the Deputy Secretary of the Army for Installations and Housing has agreed to undertake pursuant to the recommendations of the General Accounting Office in its report on May 23, 1972.
>
> "In summary, the GAO report outlines the Corps' alternatives for accomplishing the dredging workload, including: (1) maintaining the current level of effort with existing Corps plant, (2) taking over a larger share of the program by expanding the Corps plant capability, or (3) curtailing the Corps role and/or getting out of dredging completely. The Comptroller General also recommended that the Corps of Engineers should furnish the results of its comprehensive study to the appropriate Congressional legislative committees for their consideration in providing guidance as to the federal role in meeting the future national dredging requirements."

The Senate concurred with this statement (Senate Report 92-923) and added:

> ". . . (that the) comprehensive study must include consultation with the dredging industry, including their views and recommendations on various alternatives for meeting the national dredging requirements."

This study was commissioned by the Chief of Engineers and is the "National Dredging Study" by Arthur D. Little, Inc.; it is often referred to as "The Little Report." It was completed in 1974.

From the results of this study, the Chief of Engineers concluded that a program to solicit bids for work traditionally done by Corps dredges was desirable. The program would determine the interest private industry had in doing the work (TOM - test of the market) and the capability of the industry to do the work at reasonable prices and on time (ICP - industry capability program). The Corps already had authority to develop these programs. The details of the ICP are presented in a later section.

The moratorium was of considerable concern early in the GREAT I study because it specifically "placed a moratorium on all proposed plans for replacement or modification of dredges." Therefore, GREAT could not easily recommend new or different dredges and the options were severely limited. A recommended plan that included a new or different dredge would have considerably less chance of being adopted than if the moratorium were not in effect. The Team and work group decided to proceed as if the moratorium did not exist. If a new or different dredge was needed, the justification would have to be strong enough to overcome the constraint of the moratorium. In this case, a backup plan relying on existing equipment would also be developed to meet the GREAT objectives as nearly as possible.

The moratorium did not significantly affect St. Paul District operations. The District acquired the Dredge Colorado from the Water and Power Resources Service (formerly the Bureau of Reclamation) during the moratorium with the specific approval of Congress and the Office of Management and Budget on the condition that it will:

1. Be used only as a booster unit for the Thompson.

2. Not be converted to a dredge.

3. Be rehabilitated by St. Paul District.

Public Law 95-269, discussed later in detail, also lessened some of the constraints of the moratorium. This law describes a "minimum federally owned fleet" of dredges and states that this fleet "shall be maintained to technologically modern and efficient standards, including replacement as necessary." This law removed the need for GREAT to develop an "existing equipment" plan except as a tool in plan formulation.

The acquisition of new dredges by the Corps is still carefully reviewed by Congress during the budgetary process. Therefore, GREAT I plans which include a new or different dredge must also determine and evaluate the future use of existing plant.

INDUSTRY CAPABILITY PROGRAM

The original intent of the ICP as proposed by the Chief of Engineers was to determine the capability of the dredging industry to perform, at reasonable cost and in a timely manner with hopper dredges and sidecasting dredges, the dredging done in the past by the Corps. The use of cutterhead, dustpan, and mechanical dredges was added.

Several meetings were held with industry representatives to discuss details of the program during the development of procedures. Significant differences in cost accounting, labor commitments, wage and salary policies, overhead expenses, and staffing charges were identified between Corps and industry procedures. These differences called for substantial changes in the estimating procedures used by the Corps for work done under the ICP. The new accounting procedures are documented in Corps regulations ER 1110-2-1300, ER 1130-2-307, and ER 1125-2-15.

In the past, the industry and Corps selected dredging projects for the ICP through a complex series of steps. The industry began by indicating interest in bidding on particular jobs. The Districts sent lists of these sites to the Division offices. The Divisions forwarded these lists to the Chief of Engineers after attempting to package the work into easy units for bidding. On the basis of the types and amounts of work, the Chief of Engineers allocated ICP dredging to the Divisions. A minimum of 25 percent of Corps dredging nationwide was to be available for contract. The selection of jobs to be advertised was left to the Divisions.

In practice, North Central Division has reserved (not advertised) enough work to keep Corps-owned plant active even if some of the work had been listed by the industry. The rest of the dredging was then combined into units for bidding. The contracting was handled by each District.

Starting in spring 1979, all dredging in which the industry expresses interest will be advertised; none will be reserved for Corps dredges. Corps dredges will not be dispatched, except in some emergency situations, until bids have been opened on these jobs.(1) This change in policy resulted from issues raised by industry representatives at the National Dredging Meeting in November 1978 and from evaluation of the ICP.

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(1) The St. Paul District has chosen to ask contractors who have submitted bids if they would be willing to negotiate a work order for the dredging in case an emergency arises before dispatching its own fleet.

In coastal areas and harbors, shoals develop slowly enough so that contracts based on unit cost can be developed, and precontract surveys are accurate enough at the time of dredging to be reliable for pay quantities. However, on the Upper Mississippi River, shoals can develop much faster than the 30 days needed to advertise a dredging contract. Also, the volumes of dredging often change right up to the moment of dredging and a unit price or lump sum contract becomes very unwieldy. Therefore, this section of river was exempted from the policy change for 1 year. For the 1980 dredging season, St. Paul District plans to advertise a plant rental contract with standby payment provisions.

PUBLIC LAW 95-269

Public Law 95-269, passed on 28 April 1978, basically takes the ICP out of the status of a trial program and makes it law. The moratorium on acquiring new dredging equipment is replaced by the statement: ". . . shall be maintained to technologically modern and efficient standards including replacement as necessary." Also, as a part of this act, the Corps is directed to prepare a report determining ". . . the minimum federally owned fleet required to perform emergency and national defense work." The report on the hopper dredge requirement of the minimum fleet has been submitted to the Secretary of the Army, the Office of Management and Budget, and Congress. The report on nonhopper dredges is in draft form and is scheduled to be submitted to Congress in (date not yet established - the language in the law is ". . . within two years after enactment. . .").

The law stresses that:

1. As much dredging as possible be done by private industry.

2. The Corps maintain a modern minimum dredging fleet to provide for national defense and emergency operations both in the United States and abroad. This fleet is to be fully operational at all times.

Specifically, it requires that dredging be done in the most economical and advantageous way to benefit the Nation.

The following instructions on shifting from nearly exclusive Corps dredging are given in the law (exclusive of minimum fleet requirements):

1. The Corps has 4 years to shift to contract dredging the industry has shown capability to perform.

2. As the industry grows to assume more of the dredging work load, the Corps-owned fleet will be reduced.

3. The Corps-owned fleet will be no smaller than that needed to carry out emergency and national defense work.

4. The Corps will reserve the amount of work necessary to keep the minimum fleet fully operational.

5. The minimum fleet report will be prepared and submitted to Congress within 2 years.

6. No work will be done by contract if Corps plant is available to do the work and the lowest bid is over 25-percent more than the cost of dredging with the Corps plant.

7. All Government cost estimates must be based on the same factors (for example, overhead, depreciation, insurance, and capital investment interest) as the contractor's bid.

SECTION 404(T) AND OTHER REGULATORY RESTRICTIONS

In 1977, the Clean Water Act of 1965 (Public Law 92-500) was amended to include section 404(t). This amendment requires the Corps to obtain State permission for dredging the Inland Waterway System. In the GREAT I area, the Corps must ask for and be granted all the necessary dredging, placement, and fill permits from the regulatory agencies in Minnesota, Wisconsin, and Iowa. Each State's approach to this authority was discussed at the Dredging Equipment Seminar. The States' positions are given below.

Iowa Dredging Regulations

Iowa's jurisdiction over its border rivers was recently expanded through the Federal Clean Water Act of 1977 (Public Law 95-217). It now includes regulation of the Corps discharge of dredged material into the public waters of the State to meet applicable State discharge standards.

Three agencies in Iowa are directly involved: the Iowa Conservation Commission, Natural Resources Council, and Department of Environmental Quality. The coordination mechanism within the State is the Governor's Interagency Resource Council.

The Iowa Conservation Commission has jurisdiction over the sovereign lands and waters of the State. As it pertains to meandered streams within or bordering the State, State property is determined to be that land below the ordinary high-water line. In addition, the commission is concerned with fish and wildlife resources primarily through the Fish and Wildlife Coordination Act. It is also the major recreation development agency within the State and is concerned with timber growth.

As a result of the aforementioned responsibilities, a permit to satisfy section 404(t) is required for dredging and placement below the ordinary high-water mark. In addition, the commission's concerns for fish and wildlife resources must be considered under the Fish and Wildlife Coordination Act.

The Iowa Water Quality Commission of the Department of Environmental Quality regulates the quality of the waters of the State through the adoption of water quality and effluent standards. These standards are primarily implemented through the issuing of discharge permits. On 10 August 1978, the department was delegated responsibility for issuing National Pollution Discharge Elimination System (NPDES) permits pursuant to the Clean Water Act. At the present time, the department has adopted no effluent standards for dredging operations; however, the practice appears to have been affected by the water quality standards.

The most important standards limit increases in turbidity of a receiving water from a point source to 25 Nephelometric turbidity units. Total allowable dissolved solids are 750 mg/l (milligrams per liter) in a stream with a flow rate equal to or greater than three times the flow rate of upstream point source discharges. These standards apply to all classes of waters. In addition, section 401 allows the department to review 404 permits for their impacts on State environmental quality standards.

Subsection 19.3(1)(e) of the Water Quality Commission's rules specifically excludes dredging and fill discharges from permit requirements. In such a case where effluent limitations are not applied through permit, primary concern is limited to the maintenance of water quality standards.

Pursuant to this concern, it will be necessary for the Corps to submit a proposal for the conduct of a monitoring program related to dredging activities for approval by the department before the initiation of dredging.

The Iowa Natural Resources Council is responsible for floodplain management and regulation. A permit is required from the council before dredged material can be placed in a floodplain or floodway. An administrative waiver may be granted to applicants for dredging projects, provided the project is minor in scope and cannot appreciably affect flood flow. In view of the magnitude of many dredging projects, it will be necessary to clearly show that any dredged material placed within the banks of the Mississippi River is located in noneffective flow areas. If this cannot be shown, it is necessary to make formal application for council approval requesting a variance from normal criteria.

The State has been actively involved in GREAT's programs. GREAT recognizes the multiple demands/needs for the Mississippi River resource. The State encourages the Corps to comply with GREAT's recommendations as they apply to channel maintenance on the Upper Mississippi River 9-foot channel project.

To satisfy the needs of 404(t), the State will continue to work within the framework of GREAT, but will require the Corps to obtain a State permit(s). The Iowa Conservation Commission will assume the lead role in coordinating a State 404(t) permit. A permit procedure was outlined for the 1978 season. This procedure is being further evaluated for possible changes.

Assigned staff members from the Iowa Conservation Commission, Department of Environmental Quality, and Natural Resources Council are involved in the On-Site Inspection Teams of GREAT as determined necessary by the agencies. If conflicts arise during the on-site evaluations, the matter will be referred to GREAT for resolution. If the matter is not resolved to the satisfaction of the State, it will be referred to members of the Governor's Inter-Agency Resource Council for resolution. A unified State of Iowa 404(t) permit will be issued where possible.

Fourteen days before a site specific evaluation, the Corps is requested to send to all Iowa On-Site Inspection Team members the following information:

1. Identification of the proposed dredging site.

2. Detailed channel condition surveys which identify dredging requirements.

3. Physical, chemical, and biological analyses of sediments to be dredged in accordance with the approved monitoring program.

4. Identification of the proposed placement site(s).

5. Characteristics of the proposed placement site(s) (for example, topography (existing and proposed), vegetation, ownership, location with respect to floodway, and containment plans.

6. Analysis of environmental impacts of dredging and placement (that is, effects on fish and wildlife, water quality, flood stages and existing developments, vegetative cover, recreational use, and relationship to State lines).

The State wishes to emphasize the desirability of placing dredged material in areas where beneficial uses can be made of the material. In every case where dredging is required, the Corps should make every effort to place material at beneficial use sites.

Minnesota Dredging Regulations

In Minnesota, two agencies, the Pollution Control Agency and the Department of Natural Resources, carry out the primary regulatory functions which affect placement of dredged material. Both agencies are mandated under existing laws and operate under existing regulations to control dredging and the discharge and placement of dredged materials.

The Department of Natural Resources requires permits for work in public waters. Its authority is defined in State statutes (chapter 105) and in regulations promulgated in 1978 which define the standards and criteria for granting permits to change the course, current, or cross section of public waters. Public waters are any waters of the State which serve a material beneficial public purpose. Permits are required for any fill activity below the ordinary high-water mark of these waters.

The Department's policy limits the placement of fill in public waters and their shorelines to preserve their natural character and maintain suitable aquatic habitat for fish and wildlife. The Mississippi River is designated by Congress as both a fish and wildlife refuge and a Federal navigation project. These public purposes deserve State protection. Permits are issued for the placement of dredged material after a site-by-site review and evaluation of the potential impacts of the proposal and alternatives.

During the 1978 dredging season, the Corps was required to apply for only one department permit for the placement of dredged material from the 9-foot navigation channel project. The department issued a permit to the Corps for this site after evaluation of alternative dredging and placement methods. The Corps provided on-land placement of material above the ordinary high-water mark at substantially all sites last year. For 1979, as in 1978, the department will require the Corps to obtain permits after reviewing each site on an individual basis in accordance with the regulations applicable to work in public waters.

The Pollution Control Agency's authority to regulate dredge and fill activity derives from Minnesota statutes (chapters 115 and 116) which define the authority of the agency to protect water quality and specifically define dredged material as a pollutant to be regulated. The agency opposes open water placement and requires that supernatant from hydraulically dredged materials be treated before being returned to waters of the State.

During the 1978 season, the Corps and the Pollution Control Agency signed an agreement in lieu of permits when the late passage of the Clean Water Act did not permit enough time for the required administrative procedures to issue permits for the 1978 season. The stipulation was highly successful in that the Corps was able to place all dredged material on land, with confined on-land placement sites provided for hydraulically dredged material. Also, the stipulation did not result in any channel blockages. Provision for emergency dredging procedures was included in the stipulation, and a procedure for obtaining exceptions to the permit requirements was established. During the 1978 season, the Corps requested four exceptions. Three of the exceptions were granted by the agency board; however, only one of the exceptions was used because the Corps was able to provide on-land or confined on-land placement of all other dredged materials. Even where the exception was used, reduced dredging requirements allowed the material to be placed substantially on-land.

Studies were conducted during the 1978 dredging season, including effluent monitoring, comprehensive water quality sampling, sediment sampling, and bioassays. These studies will be used to determine requirements or mitigative measures for future permits.

For the 1979 dredging season, the Corps and the agency have initiated the State administrative process for permits which includes a public notice and public hearing. The primary condition of the proposed agency permit continues to be on-land placement of dredged materials with confined on-land placement of hydraulically dredged material. Provisions for emergencies and impending groundings have been included as well as a procedure for obtaining justifiable exceptions to the conditions of the permit. Strict compliance with State effluent limits will not be required; however, effluents will be monitored and the Corps best effort at obtaining compliance will be accepted as the interim limitation. Interim limitations and a 1-year permit duration will allow the following to be considered in future permit requirements.

1. The GREAT final report which is scheduled to be released in fall 1979.

2. The results of sediment and water quality analysis conducted during 1978 and 1979.

3. The Corps budgetary process, since the 1980 season is the first season that the Corps was able to allow for consideration of section 404(t).

Interagency coordination in Minnesota has been primarily conducted through the GREAT on-site inspection team process and by the personal efforts of the participants in the permitting programs. Open lines of communication are maintained between the agency, Department of Natural Resources, and all participating agencies of GREAT.

Wisconsin Dredging Regulations

The following is a summary of Wisconsin statutes that apply to the Corps dredged material placement activities:

1. Section 30.12. - This statute is the substantive law in Wisconsin which totally prohibits the open water placement of dredged material, even for such purposes as beach nourishment. It only allows the Department of Natural Resources to authorize a "structure," which is defined as anything having a discrete shape, function, and utility, and which does not result in the creation of land. Under section 30.12, the department can authorize the placement of dredged materials in the navigable waters of the State only if it is carried out in conjunction with the construction of a structure, such as a breakwater. The use of dredged material for beach nourishment or for filling between groins is not allowed under this statute.

2. Section 30.11. - This statute enables the department to authorize the placement of dredged materials in the navigable waters of the State only if the material is placed within the limits of a bulkhead line. A bulkhead line is a surveyed line which describes the limits of a fill, and it can only be used to regularize a shoreline. A bulkhead line cannot be used to create land for the riparian owner.

3. Section 147.025. - The discharge of dredged or fill materials into other "waters of the state," as that term is defined in section 147.015(13), Wisconsin Statutes, requires a discharge permit pursuant to section 147.025, Wisconsin Statutes. In addition, the discharge of effluents from existing confined placement facilities constructed by the Corps under section 123 of Public Law 91-611 requires a discharge permit pursuant to this section in accordance with section 60(a) of the 1977 Clean Water Act.

In addition, section 60(b) of Public Law 95-217 requires that Federal agencies obtain water quality certification pursuant to section 401(a) of Public Law 92-500.

The State's stringent statutory standards for approval of dredged material placement, combined with court decisions, led to the following conclusions:

1. Dredged material cannot be placed in open water.

2. Bulkhead lines and structures can only be permitted in very isolated cases and, for all practical purposes, do not exist on the river because of the volume of the material dredged and strict requirements of the law.

PROBLEMS AND NEEDS

The basic objective of the Great River Study is to develop a river system management plan that will incorporate total river resource requirements. Conflicts often occur between the actions of agencies having management responsibility on the river. These conflicts are but one of the problems associated with dredging. Where problems result from neglect of economic, environmental, or social factors, the environment, the people, and the Nation are the losers. The problems of channel maintenance dredging go beyond the scope of just the resource management aspect. The majority of these problems - both resource management and channel maintenance - are addressed by other work groups of GREAT.

To help identify the extent and severity of these problems, a series of public meetings was held in winter 1974-1975. From Minneapolis to Lansing, Iowa, the range of public attitudes and concerns was recorded. At each meeting, the GREAT program was explained and people were urged to express their opinions. They responded positively with honest, realistic, and highly useful suggestions to GREAT. People who live along the river and those who use it frequently were concerned about lost beauty and degradation of the river's recreational values. Fish and wildlife and maintenance of the 9-foot navigation channel were recognized as large-scale matters that required official regulation and review. Loss of favorite fishing pools, blocking of small-boat channels by sand, and marring of the river's beauty were realities that cut deeply.

GREAT STUDY OBJECTIVES

Following these meetings, an extensive list of problems was compiled. After the list was developed, the Team realized that it was not equipped or charged with responsibility to address all the problems. A list of criteria, based on the study objectives, was developed. These criteria defined the range of problems the Team would address. Guidelines used to identify problems are as follows:

1. The problem demonstrates a need to define Federal, State, and local government roles or a need for change in policy (such as created by traffic congestion at locks).

2. The specific problem or need is located or has significant impact within the riverine area.

3. The public has indicated concerns regarding the importance of a particular problem through newspapers, organization position papers, public meetings, or other means.

4. No other established single or joint body organization (either public or private) is currently addressing the problems or needs; or, if so, the party involved does not have the capability to adequately carry on the effort.

5. The problem or need, as well as possible solutions, has interstate or intergovernmental implications.

6. GREAT is in a unique position to pursue further study relating to the problem or need.

7. The problem reflects areas of conflict requiring a course of action.

8. GREAT has the capability to integrate the specific need with other major problems and needs of the river in reaching a solution.

9. A solution or recommendation to the problem or need can be realistically expected within the time and money constraints of GREAT.

STATEMENT OF PROBLEMS

The Material and Equipment Needs Work Group found that most of the problems identified at this point did not apply to their study objective which was to ". . . assure necessary capability to maintain the total river resources on the Upper Mississippi River in an environmentally sound manner." These identified problems from the town meetings were:

1. Economics of dredged material transportation remain the largest problem.

2. Removal of material by barge to a suitable placement site should be investigated.

3. The amount of machinery and expensive equipment used for channel maintenance is appalling and perhaps unnecessary.

4. The Corps made mistakes in building locks and dams. Corrective measures seem to add problems. Are expenditures justified on these costly mistakes?

5. Studies should be economically oriented to show funding needs, manpower, equipment, etc.

6. Could financial support be found for a conveyor system to move dredged material to the top of the bluffs?

7. Piping material many miles inland and using water for irrigation should be studied.

8. Better dredging equipment that can move material greater distances should be acquired.

Additional problem statements were derived from the 9-foot channel environmental impact statement, framework studies on the Upper Mississippi River, interagency correspondence relating to dredging, and depositions made at litigation procedures concerning dredging on the Upper Mississippi River.

The criteria listed in the previous section were applied to the identified problems. The following table shows the results of the screening process for the work group. Following the problem identification column are five columns. The first two show the problem's relevance to the GREAT I study and the work group. Problems relevant to the work group but not the GREAT I study were excluded. In many instances, a problem first thought to be relevant to a work group was eliminated from consideration through the screening process. The column marked "Time frame" indicates the time period in which the problem should be solved. The letter "S" (short term) represents the study period (1975 through 1979). The letter "M" (midterm) is the period up to 15 years following study completion. The letter "L" (long term) represents a time period 15 to 40 years following study completion. The last column of the table explains the reason for addressing or excluding a problem.

Material and Equipment Needs Work Group problem list

Problem	GREAT	Work Group	Time frame	Priority	Rationale
1. Moratorium on Federal equipment acquisition	Yes	No	L	NA	This is a policy of Congress which should be addressed by GREAT I in its final report.
2. Inadequate equipment capability in study area	Yes	Yes	L	-	The 9-foot channel EIS states that present equipment is not capable of carrying out maintenance activities in an environmentally sound manner.
3. Lack of knowledge of equipment availability and capability	Yes	Yes	L	-	Present equipment has limitations that need to be addressed. Investigation is needed to determine how to modify floating plant makeup to obtain results more compatible with environmental demands.

L = Long term.

The work group was to find later that most of the problems to be addressed surfaced during the formulation of the material placement plans and centered around means to implement a selected channel maintenance plan. These fell into three distinct areas:

1. Material transport problems. - What is the best way to get the material from the dredge cut to the placement site?

2. Material placement problems. - What is the best way to handle the material once it gets to the placement site? Is it a slurry or in a hopper at near in-place density?

3. Dredging problems. - What type and size equipment is most compatible with the transport and placement techniques suggested as solutions to the first two problems?

EXISTING EQUIPMENT SHORTCOMINGS

The main shortcoming of the dredging plant owned by the St. Paul District is size. For the volumes and frequencies developed for the selected channel maintenance plan, the Thompson appears too large and the Hauser and Dubuque appear too small.

Even though the Dredge Thompson has effectively dredged in cuts with very shallow faces (less than 1 foot), it is sized to dredge most efficiently at cut faces of 3 feet or more. It was designed and built in the late 1930's to meet the dredging requirements expected at that time. In that respect, it has functioned as designed. During the early days of the 9-foot channel project, the Thompson dredged almost exclusively in the St. Paul District and its identical sister ship, the Dredge Rock Island, was fully occupied in the Rock Island District.

Beginning in 1958, the Rock Island was transferred to the Great Lakes and then to Mobile District where it was rechristened the Dredge Collins.

Since then, the Thompson has been doing the dredging for both the St. Paul and Rock Island Districts. During the recent period of low dredging volumes (1975-1977), the Thompson has been available for additional dredging and has been used on the Illinois Waterway and Ohio River.

This gradual reduction in dredge use illustrates the advances made in river engineering technology, the stabilizing effect age has on the river, and the gradual restrainment of the channel by sedimentary and dredged material deposits. These factors combine to reduce dredging requirements. The net result is that a smaller hydraulic dredge could handle the expected dredging load in the St. Paul District. (Three possible exceptions are at Reads Landing, at Crats Island, and above Brownsville where shoaling rates can be very rapid.)

NEW EQUIPMENT REQUIREMENTS

The existing St. Paul District dredging plant has significant deficiencies in relation to GREAT I's selected channel maintenance plan. To determine what equipment changes may be needed, a set of "equipment criteria" was developed to show extremes of work that the plant should be able to perform. If the Corps were to do all the channel maintenance dredging with its own equipment and with hired labor, this set of criteria would have to be refined and probably expanded before any particular type or size dredge could be recommended. Because it is very unlikely that the Corps will be doing all the dredging for the foreseeable future, these criteria would be more wisely referred to as a general guide only.

These criteria are:

1. One-half of the total dredging volume will be moved more than 1 1/2 miles.

2. Of the recommended placement sites, 80 percent can receive material hydraulically (directly from a hydraulic dredge or hydraulically pumped from barges).

3. Of the recommended placement sites, 30 percent must leave the material so that it can be removed for beneficial use.

4. Of the dredge cuts, 10 percent require a production rate in excess of 250 cubic yards per hour.

5. Equipment should have a reaction time of 1 1/2 days to reach any cut in the study area.

6. Dredging depths range from 12 to 16 feet.

7. Dredging cut faces range from 0.5 to 2.5 feet.

PLAN FORMULATION

Since its inception, GREAT I has had as its primary goal the environmentally and economically sound placement of material dredged to maintain the 9-foot navigation channel of the Upper Mississippi River. Dredging and placement must be addressed on a short-term as well as long-term basis. For this reason, the Team developed a set of dredging recommendations before each dredging season and evaluated the dredging following each season. In addition, the Team established a procedure for notification and on-site inspection of each proposed dredging event.

Although the study effort emphasized channel maintenance, the Team's work groups have developed approximately 300 recommendations relating to all uses of the river. A number of these recommendations address channel maintenance; however, most relate to management of the many other uses of the resource. These recommendations are based on extensive research carried out as part of the study and on the expertise of the work group members.

CHANNEL MAINTENANCE

The Team proceeded from a description of how the channel maintenance dredging has been done through site selection and evaluation, material placement plan development and evaluation, to a recommended channel maintenance plan. The MENWG forms the last step in this chain of endeavors, the implementation of the plan.

The Channel Maintenance Appendix describes in detail the steps taken. This appendix contains only a brief summary of each step and an explanation of involvement of the MENWG in the process.

Possible Placement Sites

The Dredged Material Uses Work Group identified several possible placement sites for each dredge cut. At least one site was picked for each cut which emphasized a particular resource management goal or dredging strategy. The goals, called material placement categories, were selective placement, regional placement, centralized placement, beneficial use, habitat enhancement, removal from floodplain and most probable future without GREAT. These categories are defined in the Plan Formulation Work Group Appendix.

The MENWG prepared dredging cost estimates for each cut and placement site on the basis of costs incurred by the Corps at the time and the depreciation formulas used on Corps-owned equipment (the preliminary level). These costs were meant to provide input into the next step of plan development. Unfortunately, these costs were not sufficiently consistent from one piece of equipment to another to be of much value. As a result, better, more consistent estimates had to be prepared. These preliminary level estimates were used in selecting sites for the material placement plans.

Alternative Plan Development

Five material placement plans, each a complete and independent plan for the 40-year study period, were developed by the Plan Formulation Work Group. Guidelines for the selection of placement sites for each dredging cut are described in detail in the Channel Maintenance Appendix. The five plans were:

1. National economic development (NED).

2. Environmental quality (EQ).

3. Removal from floodplain (RFFP).

4. Most probable future without GREAT (MPFW/OG).

5. Selected.

The selected plan is meant to be the most balanced that could be developed with information available at that time and is the "first cut" of a recommended channel maintenance plan.

One of the major inputs to the selection of sites for the material placement plans was the dredging cost estimates prepared by the MENWG (the plan formulation level). Costs for three dredging methods were available - a 20-inch hydraulic dredge, a 12-inch hydraulic dredge, and a 2-cubic yard rated clamshell (barge-mounted 25-ton derrick). The cost rates used were based on contractors' equipment rental rates (the Blue Book) and average 1976 salaries. The program listing and rate documentation are in Attachment 2, Plan Formulation Level Cost Estimates. Production rates used were based on St. Paul District experience with the Thompson, Dubuque, and Hauser. Later in the study, dredging cost estimates for bucket-chain and hydraulic backhoe dredges were available at comparable levels.

Channel Maintenance Plan

The MENWG analysis of the selected material placement plan was a detailed cost estimating procedure for the selected plan. The program listing and cost rate documentation are described in detail in Attachment 5, Dredging Cost Estimates. These costs were based on average 1978 wages and equipment costs and followed, as much as possible, the procedures for preparing Government estimates for dredging operations according to Engineer Regulation 1110-2-1300.

Channel Reliability

The Dredging Requirements Work Group Appendix describes the relationship of channel dimensions to the reliability of the channel. Three sites are discussed in detail: Reads Landing, Crats Island, and Wilds Bend. At these sites, closures occur often. The relationship among these closures, channel dimensions, equipment production rates and response time, and barge transport costs are discussed in detail. These response times and production rates will have to be considered in preparing contract conditions and/or if St. Paul District does decide to invest in new or additional dredging plant.

Selected Material Placement Plan

The "selected" material placement plan (forerunner of the channel maintenance plan) was a reasonable attempt to balance the values of the various resources and needs of the river. The approach taken is described in detail in the Channel Maintenance Appendix.

Selected Equipment Needs Plan

Several factors tempered the work group's attempts at recommending particular equipment for maintenance of the Upper Mississippi River 9-foot navigation project. One of the work group's initial goals was removing the moratorium on new dredge acquisition (see Legal Framework and Constraints, page 47), and recommending a particular dredge for the Upper Mississippi River. As contractor interest grew, the ICP program developed, and more detailed dredging costs were available, it became apparent that developing a recommendation for one particular dredging plant would be difficult at best and not very desirable. Therefore, the goal of a selected equipment needs plan is to suggest types of equipment that may not have been considered before for the Upper Mississippi River and to suggest one or two types of equipment that would probably be the most desirable, productive, or effective in various dredging situations.

The MENWG found that contracted hydraulic equipment is available to compete with Corps dredges and that contracting problems can be lessened. Also, with certain types of mechanical dredges, the pool of potential contractors expands greatly to include general construction contractors (sewer and water, excavation, highway, etc.). Thus, competition within the private arena will be encouraged. This competition is desirable if a significant portion of the channel maintenance is to be done by contract.

The selected equipment needs plan consists of suggestions on management of the Corps fleet and its contracting procedures rather than hard and fast equipment recommendations:

1. The W. A. Thompson should be kept active as an integral part of the national minimum dredge fleet.

2. A large capacity hydraulic backhoe dredge and support fleet of tenders, barges, dozers, and end loaders should be available for bidding on channel maintenance dredging.

3. The Dubuque should be outfitted for channel maintenance dredging (increased freeboard, more sophisticated navigation and location instruments, additional pipe, and perhaps a booster) and used on as much dredging as it is suited for.

4. The Dubuque, Hauser, and Mudcat should be considered separately for dredging sediments from backwater areas and accomplishing other resource management needs.

Special Report - Isle La Plume (Placement Site 8.06)

Through the efforts of the Wisconsin Department of Natural Resources and the Dredged Material Uses Work Group, a large demand for dredged material was identified in the La Crosse, Wisconsin, area, including demand for 100,000 cubic yards of material each year for 3 years. Site 8.06 has good truck access and barged material could be easily transferred from barges or dump scows. It is close to downtown La Crosse and is accessible to potential customers.

Site 8.06 is an abandoned landfill on the southwest edge of Isle La Plume. Its most recent use was as a landfill for construction debris. The Solid Waste Division of the Wisconsin Department of Natural Resources has declared that the leachate from the site does not cause a water quality problem at present.

Special Project - Reads Landing (Placement Site 4.24)

Reads Landing, just below the mouth of the Chippewa River, is one of the most frequently dredged sites in the St. Paul District and produces a large volume of dredged material. In the past, the material was placed primarily along the left descending bank in an area known as the Nelson-Trevino bottoms. Since 1974, efforts have been made to place the dredged material on top of previously placed sand and avoid filling of undisturbed wetland areas. To maximize use of the historic placement site, a sand-diked containment area was built during the 1977 dredging season. Material dredged in 1978 was placed in the containment area with no apparent major problems.

When it became necessary to dredge the area again in 1979, the material was again placed in the containment area. However, much of the available capacity of the site had been used in 1977 and, as material filled the containment area, seepage through the sand dikes increased. A combination of seepage runoff and sloughing of the steep outside slopes resulted in encroachment of material into previously undisturbed areas. The containment area could be expanded; however, it is increasingly apparent that continued use of this site would have significant adverse environmental impacts.

One of the alternative sites considered in the various material placement plans was 4.24, an abandoned gravel pit located northwest of Wabasha, Minnesota, between U.S. Highway 61 and the Milwaukee Road Railroad Company tracks. It is estimated to have about 1.25 million cubic yards capacity without significant filling above the surrounding topography. The site could be used for at least 15 years on the basis of average annual dredging requirements.

Site 4.24 also has the potential for material removal for beneficial use which would increase the amount of time the site could be used. The site would have to be purchased or leased and approximately 1 mile of shore pipe which could be left in place would have to be installed. A supplemental booster pump may also be necessary.

The MENWG, working with St. Paul District Operations and Maintenance Branch representatives, estimated the cost of using this site, using a site on Drury Island which would be the most likely undisturbed site, and removing material from the present containment site so that it could be reused. These estimates indicated that site 4.24 would be the least costly. The estimate for the recommended site did not include the costs of a booster pump or land acquisition. If a booster pump is needed, the cost per dredging operation would increase by approximately $15,000 and the cost per cubic yard would increase about $0.23. Land acquisition, if necessary, would also increase costs.

The tentative route and photographs of the pipeline alignment are shown in Attachment 6, Exhibits and Photographs.

This proposal is discussed in more detail in the Channel Maintenance Appendix.

OTHER RIVER MANAGEMENT ACTIVITIES

Management Purposes

The GREAT I report identifies several purposes beyond those of the 9-foot navigation project which either are part of an agency's existing responsibilities or are recommendations for additional (or changes in) authorities. These purposes include fish and wildlife management, recreation, pollution control, and erosion abatement. The MENWG, in examining the large number of recommendations made by the GREAT I Team, noted that six of these purposes, in particular, implied a type of action where a dredge would be used. These purposes involved sedimentation of both granular bed load (sand from stream bank erosion) and sedimentation of suspended solids (silt and clay particles from upland erosion). Some of the approaches foreseen by the work group are remedial - dredging the material after sedimentation - and others are preventive - preventing erosion.

Construction and Equipment Needs

The "Other River Management" recommendations are listed and summarized in the following table. The reader should refer to the main report for the specific recommendation and its supporting rationale. In all cases, if an agency has the authority to take action regarding one of the recommendations and is able to get adequate funding, it should pursue cooperative arrangements with the Corps to do the work in conjunction with the Corps channel maintenance work.

Implementation of other river management recommendations

Recommendation number	Recommendation	Equipment needed (e.g., type of dredge)	Needed action
Further study 21	Rehabilitation of Weaver Bottoms (island creation)	Small hydraulic dredge (12-inch Mudcat or Pneuma pump)	Funding
Further study 20	Backwater restoration program (dredging of fine sediments)	Small dredge of any type	Funding and authority
Action item 3	Intensive maintenance and installation of riprap	Barge-mounted medium duty construction equipment (1)	Funding
Action item 10	Site plan for each placement site	Landscaping equipment	Acquisition of equipment and funding
Action item 27	Fort Snelling backwater channel	Small dredge (preferably hydraulic)	Authority and funding

(1) Suggest this work be done by contract or Hauser plant depending on assigned work load.

DEVELOPMENT OF DREDGING COST ESTIMATES

Three levels of cost estimates were developed. Each was developed to the best detail available to the MENWG at the time it was prepared. These cost estimates are described in detail in Attachments 2 and 5.

Several trends became apparent as the results of the plan evaluation cost estimates for the the selected plan were compiled. Generally, the results tend to favor a variety of equipment. This once again supports the position that for the good of the resources in the river valley as well as the dredging industry a strong program of contractor competition for channel maintenance dredging is desirable. Some of these trends are:

1. With short distances to placement sites, hydraulic (pipeline) methods tend to be less expensive.

2. At sites with smaller volumes, smaller pieces of equipment seem more efficient.

3. Unloading barges by bottom dump and hydraulic dredge is not usually cost effective except when the placement site is more than 1,000 and less than 4,000 feet inland. For distances less than 1,000 feet, unloading by crane, backhoe, or front end loader is more cost effective. Lower investment and ownership costs keep the costs of this operation competitive. Beyond 1,000 feet for mechanical unloading and 4,000 feet for 12-inch hydraulic dredge movement, trucking is needed.

4. For channel maintenance dredging of any significant scale, the MENWG felt that a "Mudcat" dredge is not a heavy-duty machine capable of sustained high production in the material usually encountered.

5. The bucket-chain dredge was competitive and should be explored by the Corps or the dredging industry. Its biggest drawback is that it is a specialized machine that cannot be used for another purpose; a hydraulic backhoe can be used for other work. The ability to meet Occupational Safety and Health Act (OSHA) requirements is questionable.

IMPLEMENTATION OF SELECTED PLAN

The key to cost effectiveness of GREAT I's channel maintenance plan is the success of efforts to develop competitive bidding between dredging contractors. The one piece of equipment that would seem to suit essentially all portions of the channel maintenance plan is a large capacity hydraulic backhoe. It seems unlikely with the investment by the Corps in the W. A. Thompson that another large investment in dredging machinery by the Corps is in the offing, particularly not in a hydraulic backhoe. With an effective contracting program, the goals of resource protection envisioned with the channel maintenance plan can be ensured through careful contract preparation and inspection.

The converse is true of the aspects of dredging related to other resource management goals and needs such as recreation and erosion control. It is much more difficult to write items such as scattered items of beach nourishment into a channel maintenance contract than to divert hired labor forces to do the work. One cost-effective way to solve this dilemma would be to reserve this work and perform it with hired labor by Government dredges for those dredging jobs on which private industry did not secure the bid.

EVALUATION OF SELECTED PLAN

The GREAT I selected plan will be very difficult to accomplish without major changes in fleet or contracting procedures from pre-GREAT practices. Fortunately, these changes are being or have been made. Any gains toward accomplishing the selected plan without the interest and investment by the private dredging industry will be lost and the schedule for implementation of the plan will be delayed 5 to 10 years (time necessary to request funds for, have money appropriated for, and acquire the equipment needed).

NATIONAL ECONOMIC DEVELOPMENT EFFECTS

The major national effect of the equipment needs portion of the GREAT I report will be to spur competition within the dredging industry. As competition develops in one region of the Inland Waterway System, the advantages of this competition will spill into other regions generating the national effect.

ENVIRONMENTAL QUALITY EFFECTS

Aside from the more direct environmental quality effects outlined in the other appendixes and the main report, the principal effects of the selected plan will be in the area of fuel economy.

RECOMMENDATIONS

The recommendations of the GREAT I Material and Equipment Needs Work Group follow.

THE DREDGE WILLIAM A. THOMPSON

The Thompson is an efficient dredge capable of many years of useful duty. However, it is too large to maintain exclusively for the 9-foot navigation project in the St. Paul and Rock Island Districts. The Material and Equipment Needs Work Group recommends that the Thompson be included in the minimum dredge fleet to the maximum extent possible. Also, the advisability of increasing the horsepower rating of its main engine should be explored to take full advantage of its pumping and dredging capability while dredging larger cuts in other parts of the inland waterway.

MECHANICAL DREDGING EQUIPMENT

A high-volume mechanical dredging plant should be available for dredging in the GREAT I area. This plant should be capable of dredging all cuts suited for mechanical dredging and transporting the dredged material to the placement site called for in the channel maintenance plan. The MENWG has no preference for public or private ownership but cautions that, if the decision is made that the plant be held privately, contracting procedures which would make it available for a significant portion of a season's dredging at a fair price must be developed.

DREDGING FORECASTS

All efforts to improve forecasts of dredging volumes, frequencies, and locations should be encouraged to improve and ease the preparation of dredging contracts.

HYDRAULIC LOADING AND UNLOADING OF BARGES

Pilot tests should be conducted of loading and unloading dredged material slurry from a barge. The work group made cursory investigations of several techniques but did not reach any definite conclusions about their use in the GREAT I area. Any tests on either technique should be done as a demonstration to which private industry operational personnel as well as interested governmental personnel would be invited.

DREDGING ESTIMATES

The plan evaluation level cost estimating program should be adopted as a tool to assist Corps of Engineers officials in preparing Government estimates for dredging.

READS LANDING

The proposals outlined in this appendix and in the Channel Maintenance Appendix for placement of material at the Wabasha gravel pit (site 4.24) should be pursued and implemented as early as possible.

FISH AND WILDLIFE MANAGEMENT

The effective management of the fish and wildlife resources on the Upper Mississippi River often requires actions to remedy the effects of upland erosion and sedimentation in backwaters or to construct certain small-scale habitat enhancement projects. To accomplish these actions, the resource management agencies, either collectively or separately, should acquire a small portable dredge capable of reaching inaccessible areas to do this type of work.

ATTACHMENT 1

PROCEEDINGS OF
DREDGING EQUIPMENT SEMINAR

By this reference the proceedings of "Dredging - A Better Way of Doing Business, The Challenge, The Technology, the Opportunity" are made an attachment to the Material and Equipment Needs Work Group Appendix to the GREAT I report. Copies are available through:

Upper Mississippi River Basin Commission
510 Federal Building
Fort Snelling
Twin Cities, Minnesota 55111

ATTACHMENT 2

PLAN FORMULATION LEVEL COST ESTIMATES

ATTACHMENT 2

PLAN FORMULATION LEVEL COST ESTIMATES

TABLE OF CONTENTS

ATTACHMENT 2

PLAN FORMULATION LEVEL COST ESTIMATES

INTRODUCTION

This attachment describes the second of the three levels of cost estimates prepared by the MENWG (Material and Equipment Needs Work Group). The first level was meant to provide a display of information on each cut and placement site in the material placement category matrix, Matrix B, from which alternative plan costs could be extracted. The third level was meant to provide a detailed evaluation of the cost of implementing the selected channel maintenance plan and to be used for dredging equipment recommendations.

The plan formulation level cost estimates were developed as a tool to be used by the Channel Maintenance Task Force to select sites for the material placement plans. They were based on published equipment rental rates (the "Blue Book") and production rates derived from Corps experience. Three methods (20-inch hydraulic, 12-inch hydraulic, and clamshell) were compared. The estimates were used in selecting the sites for each material placement plan. Later, costs of the same relative accuracy and precision were developed for a barge-mounted backhoe operation and a bucket-chain dredge. These additional data are shown in the Channel Maintenance Appendix but did not figure in the choice of sites.

PURPOSE FOR PLAN FORMULATION LEVEL

Three factors dictated that more definitive costs had to be derived for developing material placement plans from the display of sites by material placement category:

1. The preliminary level cost estimates were based on inadequate data.

2. The study time in which to develop the material placement plan was short.

3. Site-by-site analysis on a quick turnaround was needed.

Format Change

The programs written for the preliminary level estimates were designed for large numbers of similar sites and similar dredging operations. The operation of the program was completely batch and required large amounts of precoded and prechecked input data. Because of the wide diversity of placement sites and the chance for input error, a batch output was only partially usable.

The need soon arose for cost comparisons between sites for similar operations, which did not develop within the material placement categories. To meet the need for faster turnaround of this information by the Channel Maintenance Task Force and to overcome the shortcomings of the batch program, the program was modified to be interactive.

Cost Rate Change

The preliminary level cost estimates were based on Corps costs following the accounting system maintained on District-owned equipment. Because many of the dredging support costs that the Government incurs are charged against operational and other accounts, these cost rates do not reflect a true picture of the total operating costs which, for example, a contractor would have to charge against his dredging operation. Because of the urgency in assembling material placement plans, the Channel Maintenance Task Force decided to change the cost rate analysis to be based on contractors' rental rates as published by the Associated General Contractors, Inc. (AGC), in the "Blue Book". Each dredging situation was paired with a particular component of equipment within each dredging method.

The "Blue Book" data on rental rates for deck barges, scows, and towboats was not adequate to be directly usable in the same manner as the cutterhead dredging methods so adjustments were made based on recent Corps dredging-related construction contracts.

Dredging Method Change

Five dredging methods were shown on the preliminary levels - the three mentioned above plus the Mudcat and the Pneuma pump. These latter two methods are described in detail in the MENWG main report. Both were dropped from further consideration as channel maintenance dredges - the Mudcat because of its low production rate and the Pneuma pump because of its high horsepower and fuel requirements.

ASSUMPTIONS

All production rates, incidental material handling costs, and equipment selection and capability assumptions for plan formulation level cost estimates were based on St. Paul District experience, expertise from District personnel, and limited input from local contractors.

General

1. All cutterhead dredges and the Mudcat produce 15 percent solids in the slurry at all times.

2. The Pneuma pump produces 40 percent solids in the slurry at all times.

3. 100-percent containment of the slurry was assumed to be 7 days of retention.

4. A dike is defined as a structure to physically contain the dredged material.

5. Berming is the deployment of two additional dozers to direct the dredge discharge during dredging.

6. When the placement site is farther from the cut than can be reached by the pipeline length of the hydraulic dredges, a procedure called "bathtubbing" is followed. Step-by-step this process is:

a. A site suitable for bathtubbing is assumed to be available within 1,500 feet of the dredging cut.

b. An amount of material equal to the volume to be dredged is removed from this intermediate site by mechanical means (dragline or clamshell) and transported to the placement site by barge.

c. The material is moved from the barge to the placement site by a method appropriate to the dredged material and the placement site. These methods will be described in later assumptions.

d. If required, a diked containment area is built at the intermediate site.

e. The cut is dredged hydraulically with placement at the intermediate site.

f. The intermediate site is restored to nearly its original condition.

7. The following cost rates are assumed for each piece of equipment:

Equipment	Per day rental cost	Per hour operating cost
20-inch dredge	$1,922	$99.00
1,000-hp tender	360	30.00
380-hp tender	174	13.20
175-hp tender	90	4.30
120-foot deck barge	342	7.75
150-foot deck barge	921	21.40
Anchor barge	270	10.50
Hoist for anchor barge	106	3.80
20-inch booster	560	13.10
12-inch dredge	281	60.75
8-inch Mudcat dredge	1,305	22.50
Mudcat transport unit	249	22.60
8-inch booster unit	114	7.00
Skiff	30	9.60
Derrickbarge (25 ton)	948	85.80
Cranebarge (20 ton)	632	41.00
200-cubic yard dump scow	552	31.90
500-cubic yard dump scow	828	48.00
Pneuma pump dredge	4,119	180.00
80-hp dozer	65	0
130-hp dozer	80	0
20-hp dozer	45	0

20-Inch Hydraulic Dredge

1. It would not be used on the Minnesota River.

2. The equipment complement depends on the distance from dredge cut to placement site as follows:

Up to 1,750 feet	1,750 to 8,000 feet
1 20-inch dredge	1 20-inch dredge
1 1,000-hp tender	1 20-inch booster
3 380-hp tenders	1 1,000-hp tender
1 175-hp tender	4 380-hp tenders
1 anchor barge with hoist	1 175-hp tender
	1 anchor barge with hoist

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2/5

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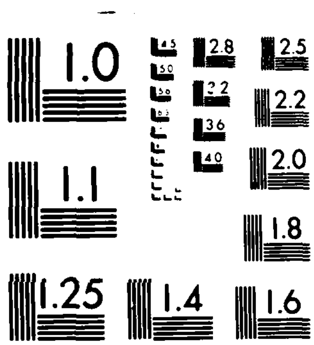

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

3. The cubic yard per hour production rate and productive hours per day functions are shown on pages 6-2 and 6-3.

4. For cut to placement site distances less than 2,750 feet, mobilization requires 1 day. For more than 2,750 but less than 4,400 feet, mobilization requires 2 days. For more than 4,400 up to 8,000 feet, mobilization requires 3 days.

Diking (When Needed)

1. All diked areas are square.

2. All sites are assumed flat and level before work begins.

3. Dikes are built of material excavated from the interior of the basin.

4. Costs of constructing dikes are based on St. Paul District experience with contracting the construction of similar diked containment areas.

5. Basin and dike size are functions of seepage rate, retention time, volume of slurry pumped, and a limit on dike height.

6. Basins are sized to hold all dredged material plus all slurry pumped minus water lost through seepage minus any effluent that might develop after the required retention time.

7. The detailed print-out will show the flow (in cubic feet per second) that will develop in an outlet structure.

8. All dikes have the same cross-section: 10-foot level top, 1:10 outside slope, and 1:4 interior slopes.

9. To calculate area required, a square area measured from toe-of-slope to toe-of-slope was used.

10. The diked areas were managed and rehabilitated by several means depending on frequency of use. If used less often than every 5 years, the dikes were collapsed and the site left in a slightly rolling appearance. If used every 3 to 5 years, the dikes were vegetated or otherwise made stable until the next use. If used at least every other year, the site was not reshaped or modified except for erosion protection.

11. To compute the area required at a site for the entire study period (40 years), the material on the site is assumed to be piled in a pyramidal shape with 1:8 side slopes to a height one-fortieth the length of a side. If the upper limit (defined in the input for each site) is reached before the total volume is accommodated, the length of the pile sides is increased without increasing pile height.

Berming (When Needed)

The rental cost of two dozers for the entire time of dredging operations and mobilization is added to the dredging cost.

Trucking

Costs are based on volume of material to be moved by a complement of equipment including trucks, end loaders, conveyor belts, and dozers. The frequency of dredging determines the appropriate combination.

Barge Unloading (When Needed)

1. Costs of direct unloading by barge were on a cost per cubic yard based on information provided by sand and gravel operators in the study area.

2. In-water rehandling of the material calls for transport in split-bottom dump scows, a 12-inch dredge stationed near shore, scows to unload above the cutterhead, and hydraulic transport inland to the placement site.

3. If the placement site is more than 3,000 feet from a suitable location for the 12-inch dredge, the material was pumped to a temporary site and trucked to the placement site.

12-Inch Hydraulic Dredge

1. The equipment complement in all direct dredging situations was:

1 - 12-inch dredge
1 - 1,000-hp tender
2 - 380-hp tenders
1 - 175-hp tender
1 - Anchor barge with hoist

2. The cubic yard per hour production rate and productive hours per day functions are shown on pages 6-2 and 6-3.

3. For cut to placement site distances less than 1,750 feet, mobilization requires 1 day. Other distances require 2 days.

Clamshell Dredge

1. The equipment complement for the dredging operation (loading barges) and placement operation (unloading barges) in all situations was:

1 - 25-ton rated barge-mounted derrick (Hauser)
1 - 25-ton rated barge-mounted crane (Wade)
1 - 1,000-hp tender
1 - 380-hp tender
2 - 175-hp tenders

2. The cubic yard per hour production rate and production hours per day functions are shown on pages 6-2 and 6-3.

3. Cost of transport was a function of distance and volume and was based on information supplied by sand and gravel operators in the study area.

4. All mobilization required 1 day at each dredging cut.

PROGRAM LISTING

The program used is listed on the following pages. The assumptions in the previous section form the basis on which the program logic rests. Care should be taken in using this program on any other waterway because the seepage rates and production functions are directely tied to the conditions on the Upper Mississippi River.

```
      PROGRAM CDREDGE(INPUT,OUTPUT,TAPE30=INPUT)
C
      DIMENSION AREA(7),PILE(7),AREA40(7),PILE40(7),DATE(7),SPEC(5)
      DIMENSION ESTCST(7),UNIT(7),ANNCST(7),DKF(7),NAME(5),CSTBRM(7)
      DIMENSION DURGE(3),MUDCAT(3),FLTBD(3),BOOST(3),SKIFF(3),HAUSER(3)
      DIMENSION WADE(3),THOMP(3),TD1000(3),TD380(3),TD175(3),ANCH(3)
      DIMENSION DP200(3),DP500(3),DK120(3),DK150(3),HOIST(3),MULI(3)
      DIMENSION PNEUMA(3),SLURRY(5),D7(3),D9(3),JD450(3)
      INTEGER  POOL,  CUT, PREP, TDAY, DATE, NAME, METHOD, Y, INTER
      INTEGER  DYKE, LAND, TRUCK, BERM, ANSWER, SWITCH, WATER, TRSTYP
C
      REAL  PILE, HEIGHT, CSTDUB, LPILE
      REAL  DIST, HGHT, DOLLR, HT, FREQ,  CUYDS
      REAL  LFNEQV, PROD, DAYS, CSTTHM, CSTLD, LFNMI, CSTMV
      REAL  CSTSHP, CSTDRG, DKVOL, PDKCST, CSTCIN, CSTIND, CSTRD
      REAL  CSTELD, CSTCNV, CSTHL, CSTSHL, CSTSHD, CSTDUB
      REAL  CSTPNE, CSTHAU, CSTTRP,CSTWD, DISTSH, CSTSPG
      REAL HOIST,MULL,MUDCAT,HAUSER, LSIDE, UNLOAD, LENGTH
      REAL DURGE,FLTBD,BOOST,SKIFF,WADE,THOMP,TD1000
      REAL TD380,TD175,ANCH,DP200,DP500,DK120,DK150
      REAL PNEUMA,SLURRY, SIZE, WLDDAY
C
      DATA SLURRY/.15,.15,100.,40.,15/
      DATA THOMP/1922.,0.99./
      DATA TD1000/360.,0.30./
      DATA TD380/174.,0.13,20/
      DATA TD175/90.,0.4,80/
      DATA DK120/392.,0.7,75/
      DATA DK150/921.,0.21,40/
      DATA ANCH/270.,0.10,50/
      DATA HOIST/106.,0.3,80/
      DATA MULL/560.,0.13,10/
      DATA DURGE/281.,0.60,75/
      DATA MUDCAT/1305.,0.22,50/
      DATA FLTBD/289.,0.22,60/
      DATA BOOST/119.,0.7./
      DATA SKIFF/30.,0.9,60/
      DATA HAUSER/948.,0.85,80/
      DATA WADE/632.,0.41./
      DATA DP200/552.,0.31,90/
      DATA DP500/828.,0.48./
      DATA PNEUMA/8119.,0.180./
      DATA D7/65,0.0/
      DATA D9/80,0.0/
      DATA JD450/45.0.0/
C
C
      TYPO = 0
      PRINT 3000
 3000 FORMAT(10X,21HDREDGING COST PROGRAM,//)
      PRINT 3001
 3001 FORMAT (26HPLEASE ENTER TODAY'S DATE ,5X,8HMM-DD-YY,/)
      READ (30,3002) DATE
 3002 FORMAT (A8)
      PRINT 3003
 3003 FORMAT (//56HIF YOU EVER WANT TO STOP IN THE MIDDLE OF A COMPUTATI
     1ON /44HTYPE "STOP" WHEN ASKED A YES OR NO QUESTION.//)
      PRINT 3004
 3004 FORMAT (/68HDO YOU WANT JUST THE SITE SUMMARY RATHER THAN THE DETA
     1ILED PRINTOUT?)
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9010 READ (30,3102) SWITCH
     IF (SWITCH .EQ. 1HS) GO TO 5001
     IF ((SWITCH .EQ. 1HY) .OR. (SWITCH .EQ. 1HN)) GO TO 10
C    PRINT (9001,9002,9003,9004,9005) TYPO
     IF (TYPO .LE. 5) TYPO = TYPO + 1
     GO TO 9010
  10 PRINT 3005
     DOLLR = 0.0
3005 FORMAT (51HTYPE IN IDENTIFYING NAME FOR CUT AND DISPOSAL SITE ./)
     READ (30,3006) (NAME(I),I=1,5)
3006 FORMAT (5A10)
     PRINT 3010
3010 FORMAT (11HDATA INPUT ,//7H  POOL ,10X,9HEXAMPLES ,3X,13H03 FOR PO
    1OL 3,/29X,22HMN FOR MINNESOTA RIVER,/29X,22HSC FOR ST. CROIX RIVER
    1)
     READ (30,3101) POOL
3101 FORMAT (A2)
     IF (POOL .EQ.2H03) GO TO 5
     GO TO 6
   5 PRINT 3011
3011 FORMAT (/26H  IS CUT ABOVE LAKE PEPIN?)
9011 READ (30,3102) CUT
     IF (CUT .EQ. 1HS) GO TO 5001
     IF ((CUT .EQ. 1HY) .OR. (CUT .EQ. 1HN)) GO TO 6
C    PRINT (9001,9002,9003,9004,9005) TYPO
     IF (TYPO .LE. 5) TYPO = TYPO + 1
     GO TO 9011
3102 FORMAT (A1)
   6 PRINT 3012
3012 FORMAT (/25H  RETENTION TIME IN DAYS )
     READ (30,*) TDAY
     PRINT 3013
3013 FORMAT (/22H  CUBIC YARDS DREDGED )
     READ (30,*) CUYDS
     PRINT 3014
3014 FORMAT (/24H  FREQUENCY OF DREDGING )
     READ (30,*) FREQ
     PRINT 3015
3015 FORMAT (/36H  DISTANCE TO DISPOSAL SITE IN FEET )
     READ (30,*) DIST
     PRINT 3016
3016 FORMAT (/27H  HOW HIGH IS DISPOSAL SITE,/35H  ABOVE LOW CONTROL PO
    1OL ELEVATION?)
     READ (30,*) HGHT
     PRINT 3017
3017 FORMAT (/19H  IS DIKING NEEDED?)
9013 READ (30,3102) DIKE
     IF (DIKE .EQ. 1HS) GO TO 5001
     IF ((DIKE .EQ. 1HY) .OR. (DIKE .EQ. 1HN)) GO TO 9012
C    PRINT (9001,9002,9003,9004,9005) TYPO
     IF (TYPO .LE. 5) TYPO = TYPO + 1
     GO TO 9013
9012 IF (DIKE .EQ. 1HY) GO TO 15
     PRINT 3018
3018 FORMAT (/20H  IS BERMING NEEDED?)
9014 READ (30,3102) BERM
     IF (BERM .EQ. 1HS) GO TO 5001
     IF ((BERM .EQ. 1HY) .OR. (BERM .EQ. 1HN)) GO TO 15
C    PRINT (9001,9002,9003,9004,9005) TYPO
     IF (TYPO .LE. 5) TYPO = TYPO + 1
```

```
      GO TO 9014
   15 PRINT 3019
 3019 FORMAT (/40H  MAXIMUM HEIGHT OF DIKE OR BERM ALLOWED )
      READ (30,*) HT
      PRINT 3020
 3020 FORMAT (/33H  IS RESHAPING FOR RECREATION OR,/21H  OTHER USE REQUI
     1RED?)
 9016 READ (30,3102) LAND
      IF (LAND .EQ. 1HS) GO TO 5001
      IF ((LAND .EQ. 1HY) .OR. (LAND .EQ. 1HN)) GO TO 9015
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9016
 9015 PRINT 3021
 3021 FORMAT (/24H  IS TRUCKING NECESSARY?)
 9018 READ (30,3102) TRUCK
      IF (TRUCK .EQ. 1HS) GO TO 5001
      IF ((TRUCK .EQ. 1HY) .OR. (TRUCK .EQ. 1HN)) GO TO 9017
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9018
 9017 IF (TRUCK .EQ. 1HN) GO TO 20
      PRINT 3022
 3022 FORMAT (/17H  HOW MANY MILES?)
      READ (30,*) DISTSH
      PRINT 3025
 3025 FORMAT (/18HTHROUGH WHAT SITE?)
      READ (30,3103) TRSITE
 3103 FORMAT (A5)
   20 PRINT 3023
 3023 FORMAT (/30H  IS ANY SPECIAL CONSTRUCTION REQUIRED?)
 9020 READ (30,3102) PREP
      IF (PREP .EQ. 1HS) GO TO 5001
      IF ((PREP .EQ. 1HY) .OR. (PREP .EQ. 1HN)) GO TO 9019
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9020
 9019 IF (PREP .EQ. 1HN) GO TO 25
      PRINT 3026
 3026 FORMAT (/19HDESCRIBE IT PLEASE.)
      READ (30,3006) (SPEC(I),I=1,5)
      PRINT 3024
 3024 FORMAT (/40H  ESTIMATE OF SPECIAL CONSTRUCTION COST )
      READ (30,*) DOLLR
   25 CONTINUE
C
   36 FORMAT (//15H PROD DAYS USED,2X,I3)
C
      WATER = 0.
      LENMI=DIST/5280.
C
C *************************************
C     THOMPSON-MULLEN FLOW  METHOD 1
C *************************************
C
   10 METHOD= 1
      IF (SWITCH .EQ. 1HN) PRINT 3050,(NAME(I),I=1,5),DATE
 3050 FORMAT (////5X,5A10,7X,6HPAGE 1,/60X,A8)
      PRINT 3030
 3030 FORMAT (//29HFOR 20-INCH HYDRAULIC DREDGE /)
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```
      IF (POOL .NE. 3HMN) GO TO 30
      IF (SWITCH .EQ. 1HN) PRINT 3031
 3031 FORMAT (/38H  DREDGE TOO LARGE FOR MINNESOTA RIVER)
      GO TO 200
   30 LFNEQV= DIST + (HGHT/0.025)
      IF (LFNEQV .LE. 1750) GO TO 100
      IF ((1750 .LT. LFNEQV) .AND. (LFNEQV .LE. 2750)) GO TO 110
      IF ((2750 .LT. LFNEQV) .AND. (LFNEQV .LE. 4400)) GO TO 120
      IF ((4400 .LT. LFNEQV) .AND. (LFNEQV .LE. 8000)) GO TO 130
      IF (LFNEQV .GT. 8000) GO TO 140
C
 100  HOURS=20.0-(0.0017*LFNEQV)
      PROD=(1270.0-(0.17*LFNEQV))*HOURS
      DAYS= (CUYDS/PROD) + 1.0
      CSTTHM=DAYS*(THOMP(1)+TD1000(1)+(3*TD380(1))+TD175(1)+ANCH(1)+
     1HOIST(1))+HOURS*DAYS*(THOMP(3)+TD175(3)+ANCH(3)+HOIST(3))+
     1(24-HOURS)*DAYS*(TD1000(3)+(3*TD380(3)))
      IF (SWITCH .EQ. 1HN) PRINT 3032,DAYS,HOURS,CSTTHM
 3032 FORMAT (/36H  NO BOOSTER NEEDED. DREDGING TAKES ,F3.0,
     116H DAYS OPERATING ,F3.0,13H HOURS A DAY //
     126H  PRIMARY DREDGING COSTS $,F11.2)
      GO TO 160
C
 110  HOURS=15.5-(0.00056*LFNEQV)
      PROD=(1270.0-(0.17*LFNEQV))*HOURS
      DAYS= (CUYDS/PROD) + 1.0
      CSTTHM=DAYS*(THOMP(1)+MULL(1)+TD1000(1)+(4*TD380(1))+TD175(1)+
     1ANCH(1)+HOIST(1))+HOURS*DAYS*(THOMP(3)+MULL(3)+TD175(3)+ANCH(3)+
     1HOIST(3))+(24-HOURS)*DAYS*(TD1000(3)+(4*TD380(3)))
      IF (SWITCH .EQ. 1HN) PRINT 3033,DAYS,HOURS,CSTTHM
 3033 FORMAT (31H  BOOSTER USED. DREDGING TAKES ,F3.0,
     116H DAYS OPERATING ,F3.0,13H HOURS A DAY //
     126H  PRIMARY DREDGING COSTS $,F11.2)
      GO TO 160
C
 120  HOURS=15.5-(0.00056*LFNEQV)
      PROD=(1130.0-(0.12*LFNEQV))*HOURS
      DAYS= (CUYDS/PROD) + 2.0
      CSTTHM=DAYS*(THOMP(1)+MULL(1)+TD1000(1)+(4*TD380(1))+TD175(1)+
     1ANCH(1)+HOIST(1))+HOURS*DAYS*(THOMP(3)+MULL(3)+TD175(3)+ANCH(3)+
     1HOIST(3))+(24-HOURS)*DAYS*(TD1000(3)+(4*TD380(3)))
      IF (SWITCH .EQ. 1HN) PRINT 3034,DAYS,CSTTHM,HOURS
 3034 FORMAT (33H  BOOSTER NEEDED. DREDGING TAKES ,F3.0,5H DAYS,/13H  AN
     1D COSTS $,F11.2,10H DREDGE IN,/6H  USE ,F3.0,13H HOURS A DAY.)
      GO TO 160
C
  130 HOURS=13.0
      PROD=(967.0-(0.083*LFNEQV))*HOURS
      DAYS= (CUYDS/PROD) + 3.0
      CSTTHM=DAYS*(THOMP(1)+MULL(1)+TD1000(1)+(4*TD380(1))+TD175(1)+
     1ANCH(1)+HOIST(1))+HOURS*DAYS*(THOMP(3)+MULL(3)+TD175(3)+ANCH(3)+
     1HOIST(3))+(24-HOURS)*DAYS*TD1000(3)+(4*TD380(3))
      IF (DIST .GE. 6800) GO TO 35
      IF (SWITCH .EQ. 1HN) PRINT 3035,DAYS,CSTTHM,HOURS
 3035 FORMAT (38H  BOOSTER NEEDED. WE HAVE ENOUGH PIPE,/17H  DREDGING TA
     1KES ,F3.0,18H DAYS. AND COSTS $,F11.2,10H DREDGE IN,/6H  USE ,F3.0
     1,13H HOURS A DAY.)
      GO TO 160
   35 PIPE = DIST-6800
      IF (SWITCH .EQ. 1HN) PRINT 3036,PIPE,DAYS,CSTTHM,HOURS
```

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 3036 FORMAT (18H  BOOSTER NEEDED. ,F4.0,28H FEET OF NEW PIPE IS NEEDED.
     1,/17H  DREDGING TAKES ,F3.0,17H DAYS AND COSTS $,F11.2,10H DREDGE
     1IN./6H  USE ,F3.0,13H HOURS A DAY.)
      GO TO 160
C
C
  140 HOURS = 17
      PROD = 11680.0
      DAYS = (CUYDS/PROD)+1.
      CSTTHM=DAYS*(THOMP(1)+TD1000(1)+(3*TD380(1))+TD175(1)+ANCH(1)+
     1HOIST(1))+HOURS*DAYS*(THOMP(3)+TD175(3)+ANCH(3)+HOIST(3))+
     1(24-HOURS)*DAYS*(TD1000(3)+(3*TD380(3)))
      IF (SWITCH .EQ. 1HN) PRINT 3037,DAYS,CSTTHM,HOURS
 3037 FORMAT (55H  CALLS FOR BATHTUBBING THE MATERIAL, DREDGING INTO THE
     1,/26H  INTERMEDIATE SITE TAKES ,F3.0,16H DAYS, AND COSTS,F11.2,10H
     1 DREDGE IN./6H  USE ,F3.0,13H HOURS A DAY.)
      TUB=SHYES
C
C     LOAD AND MOVE FROM INTERMEDIATE SITE
C
  750 IF (CUYDS .LE. 20000)
     1     CSTLD= (2.34-(0.000042*CUYDS)) * CUYDS
      IF ((20000 .LT. CUYDS) .AND. (CUYDS .LE. 40000))
     1     CSTLD= (1.75-(0.000025*CUYDS)) * CUYDS
      IF (CUYDS .GT. 40000)
     1     CSTLD= 0.75 * CUYDS
C
C
C     COST-MOVE CALCULATIONS
C
      IF ((0 .LT. LENMI) .AND. (LENMI .LE. 10))
     1  CSTMV = CUYDS*((.067*LENMI)+.33)
      IF ((10 .LT. LENMI) .AND. (LENMI .LE. 20))
     1  CSTMV = CUYDS*((.03*LENMI)+.7)
      IF (LENMI .GT. 20)
     1  CSTMV = CUYDS*((.06*LENMI)+.1)
      IF (SWITCH .EQ. 1HN) PRINT 3038,CSTLD,CSTMV
 3038 FORMAT (/67H  LOADING THE MATERIAL INTO BARGES FROM THE INTERMEDIA
     1TE SITE COSTS/3H  $,F10.2,48H MOVING THE LOADED BARGES TO THE REHA
     1NDLING SITE/10H  COSTS $ ,F10.2)
C
  760 PRINT 3041
 3041 FORMAT (/53HIS THIS BARGED MATERIAL TO BE REHANDLED IN THE WATER?)
 9022 READ (30,3102) WATER
      IF (WATER .EQ. 1HS) GO TO 5001
      IF ((WATER .EQ. 1HY) .OR. (WATER .EQ. 1HN)) GO TO 9021
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9022
 9021 IF (WATER .EQ. 1HY) GO TO 150
C
C ********************
C   DIRECT UNLOADING
C ********************
C
 6000 PRINT 6001
 6001 FORMAT (/61HTHE BLACK BOX ASSUMES OFF-LOADING AT THE REHANDLING SI
     1TE WITH/46HA CLAMSHELL.  IS THIS THE FINAL DISPOSAL SITE?)
 9024 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
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      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9023
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9024
 9023 IF (ANSWER .EQ. 1HY) GO TO 6100
      IF (TRUCK .EQ. 1HN) GO TO 6001
      PRINT 6902,DISTSH,TRSITE
 6902 FORMAT (/67HDID YOU ACCOUNT FOR MOVING THE MATERIAL FROM THE REHAN
     1DLING SITE TO/50HTHE DISPOSAL SITE WHEN YOU CALLED FOR TRUCKING IT
     1 ,F3.0,14H MILES THROUGH/5HSITE ,A5,1H?)
 9026 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9025
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9026
 9025 IF (ANSWER .EQ. 1HY) GO TO 6100
      PRINT 6903
 6903 FORMAT (/69HBECAUSE THE BLACK BOX ASSUMES YOU MUST TRUCK IT TO THE
     1 DISPOSAL SITE,/42HPLEASE ENTER THE TOTAL DISTANCE  (IN FEET))
      READ (30,*) DISTSH
      GO TO 6100
 6001 PRINT 6904
 6904 FORMAT (/60HTHE MATERIAL MUST BE TRUCKED FROM THE REHANDLING SITE
     1TO THE DISPOSAL/30HSITE.  HOW MANY MILES IS THIS?)
      READ (30,*) DISTSH
      TRUCK = 1HY
 6100 IF (CUYDS .LE. 20000) UNLOAD = (2.-(.00005*CUYDS))*CUYDS
      IF ((20000 .LT. CUYDS) .AND. (CUYDS .LT. 40000)) UNLOAD = CUYDS
      IF (CUYDS .GT. 40000) UNLOAD = ((.000033*CUYDS)-.33)*CUYDS
      IF (SWITCH .EQ. 1HN) PRINT 3042,UNLOAD
 3042 FORMAT (/34HUNLOADING THE BARGES AT THE DISPOSAL/29HSITE WITH A C
     1LAMSHELL COSTS $,F10.2)
      GO TO (160,250,310) METHOD
C
C     ==========================
C       IN-WATER REHANDLING
C     ==========================
C
 7000 PRINT 7901,HGHT,DIST,LENMI
 7901 FORMAT (/65HTHE BLACK BOX ASSUMES REHANDLING WITH A 12-INCH HYDRAU
     1LIC DREDGE./12HTHE SITE IS ,F3.0,25H FT. ABOVE LCP ELEV. AND ,
     1F6.0,2H (,F5.2,10H MI.) FROM THE./51HCUT.  ARE THESE VALID FOR THE
     1 REHANDLING OPERATION?)
 9028 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9027
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9028
 9027 IF (ANSWER .EQ. 1HY) GO TO 150
      PRINT 7902,HGHT
 7902 FORMAT (/21HIS THE DISPOSAL SITE ,F3.0,15H FT. ABOVE LCP?)
 9030 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9029
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9030
 9029 IF (ANSWER .EQ. 1HY) GO TO 151
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      PRINT 3205
      READ (30,*) HGHT
  151 PRINT 7903,DIST,LENMI
 7903 FORMAT (/32HIS THE IN-WATER REHANDLING SITE ,F6.0,2H (,F5.2,
     110H MI.) FROM THE CUT?)
 9032 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9031
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9032
 9031 IF (ANSWER .EQ. 1HY) GO TO 150
      PRINT 7904
 7904 FORMAT (/44HHOW FAR IS THE REHANDLING SITE FROM THE CUT?)
      READ (30,*) DIST
      LENMI=DIST/5280.
  150 PRINT 7905
 7905 FORMAT (/34HHOW FAR INLAND IS THE DISPOSAL SITE?)
      READ (30,*) LENGTH
      IF (LENGTH .LT. 3000) GO TO 153
      PRINT 7906,LENGTH
 7906 FORMAT (/F6.0,56H FT. IS BEYOND THE REACH OF MOST 12-INCH DREDGES
     1WITHOUT/57HMODIFICATION.  PLEASE RECONSIDER YOUR DREDGING PROCEDUR
     1E.)
      GO TO 740
  153 HOURS = 15.-(.0017*(LENGTH+HGHT/.094))
      PRODT = (330.-(.094*LENGTH))*HOURS
      IF((PRODT.GT.(200*HOURS)) .AND. (SWITCH .EQ. 1HN))PRINT 3044,PRODT
 3044 FORMAT (/28HTHE 12-INCH DREDGE CAN PUMP ,F8.0,35H CUBIC YARDS PER
     1DAY INTO THIS SITE/67HWHICH IS FASTER THAN THE HAUSER AND WADE, WO
     1RKING TOGETHER CAN LOAD/37HTHE BARGES FROM THE INTERMEDIATE SITE/)
  152 ULDDAY = CUYDS/PRODT
      UNLOAD = ULDDAY*(DURBE(1)+TD3RO(1)+ANCH(1))+HOURS*ULDDAY*(DURBE(3)
     1+TD3RO(3)+ANCH(3))
      IF (PRODT .LE. (200*HOURS)) GO TO 155
      IF (SWITCH .EQ. 1HN) PRINT 3045,UNLOAD,ULDDAY
 3045 FORMAT  (60HIF THE BARGES COULD BE LOADED FASTER, THE 12-INCH DRED
     1GE COULD UNLOAD/14HTHE BARGES IN ,F3.0,20H DAYS AT A COST OF $,
     1F10.2)
      IF (SWITCH .EQ. 1HN) PRINT 3046
 3046 FORMAT (70HIF THE BARGES MUST BE LOADED AT THE INTERMEDIATE SITE W
     1ITH A CLAMSHELL)
      PRODT = 200*HOURS
      GO TO 152
  155 IF (SWITCH .EQ. 1HN) PRINT 3047,UNLOAD,ULDDAY
 3047 FORMAT (65HUNLOADING THE BARGES AT THE REHANDLING SITE WITH A 12-I
     1NCH DREDGE/7HCOSTS $,F10.2,11H AND TAKES ,F3.0,6H DAYS.)
      GO TO (160,250,310) METHOD
C
C
  160 IF (METHOD .EQ. 1) CSTDRG = CSTTHM+CSTLD+CSTMV+UNLOAD
      DAZE(METHOD) = DAYS
C
C ******************
C     DIKING FLOW
C ******************
C
  600 IF (DIKE .EQ. 1HN) GO TO 6600
      IF ((TUB .EQ. 3HYES) .AND. (PRODT .EQ. 0))
     1PRODT = (330.-(.094*LENGTH))*HOURS
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```
      IF (TUB .EQ. 3HYES) INTER = 3HYES
  601 DRDAYS= CUYDS/PROD
      IF (DRDAYS .LE. IDAY) VLPMPD = 27*CUYDS/SLURRY(METHOD)
      IF (DRDAYS .GT. IDAY) VLPMPD =27*((CUYDS/SLURRY(METHOD)-CUYDS)*
     1(IDAY/DRDAYS) + CUYDS)
C
      LNDIKE =.0005*VLPMPD+850.
C
C     DETERMINE VOLUME LOST BY SEEPAGE
C
  605 IF (POOL .EQ. 2H04) GO TO 608
      IF ((POOL .EQ. 2H01) .OR. (POOL .EQ. 2H02) .OR. (POOL .EQ. 2H03)
     1 .OR. (POOL .EQ. 2HSC) .OR. (POOL .EQ. 2HMN)) GO TO 609
  613 IF (HT.LE. 5)VLSEEP = LNDIKE*.75*IDAY*21.*27.
      IF (HT .GT. 5) VLSEEP = LNDIKE*.75*IDAY*32.*27.
      GO TO 612
  609 IF (HT .LE. 5) VLSEEP = LNDIKE*.75*IDAY*4.5*27.
      IF (HT .GT. 5) VLSEEP = LNDIKE*.75*IDAY*6.*27.
      GO TO 612
  608 IF (CUT .EQ. 1HY) GO TO 609
      GO TO 613
  612 VLREQD = VLPMPD - VLSEEP
      IF (VLREQD .LT. (CUYDS*27))  VLREQD = CUYDS*27
      IF (INTER .NE. 3HYES) GO TO 602
      VLREQD = VLREQD -(CUYDS*27.)
      IF (VLREQD .GT. 0) GO TO 603
      IF (SWITCH .EQ. 1HN) PRINT 3603
 3603 FORMAT (/47HINTERMEDIATE SITE WILL HOLD SLURRY THE REQUIRED,/19HTI
     1ME WITHOUT DIKING)
      INTER = 2HNO
      PROD = PRODT
      GO TO 601
  603 IF (SWITCH .EQ. 1HN) PRINT 3604
 3604 FORMAT (//26HFOR THE INTERMEDIATE SITE )
      GO TO 606
  602 IF (TUB .EQ. 3HYES) PRINT 3613
 3613 FORMAT (//34HFOR DIKING AT THE REHANDLING SITE )
      GO TO 606
  606 SIZE = VLREQD/27.
C
C     DETERMINE IF DROP STRUCTURE IS NEEDED
C
      VSLR = (PROD /SLURRY(METHOD)-PROD)*27.
      IF (VSLR .LE. VLSEEP)  GO TO 607
      IF ((VSLR*DRDAYS) .LE. (VLSEEP*IDAY)) GO TO 607
      IF ((METHOD .EQ. 1) .AND. (TUB .NE. 3HYES))
     1CDROP = ((DAYS+.5)/DAYS)*CSTTHM/DAYS
      IF  ((METHOD .EQ. 2) .OR. (METHOD .EQ. 3) .OR. (TUB .EQ. 3HYES))
     1CDROP = ((DAYS+.5)/DAYS)*CSTDUR/DAYS
      IF  ((METHOD .EQ. 4) .AND. (TUB .NE. 3HYES))
     1CDROP = ((DAYS+.5)/DAYS)*CSTPNE/DAYS
      IF  ((METHOD .EQ. 5) .AND. (TUB .NE. 3HYES))
     1CDROP = ((DAYS+.5)/DAYS)*CSTMUD/DAYS
C
      IF (CDROP .LE. 0) GO TO 607
      IF (SWITCH .EQ. 1HN) PRINT 3605,CDROP
 3605 FORMAT (/28H  A DROP STRUCTURE COSTING $,F8.2,10H IS NEEDED,/)
      FLOW = (VSLR-VLSEEP)/(24*60*60)
      IF (SWITCH .EQ. 1HN) PRINT 3612,FLOW
 3612 FORMAT (35H  AVERAGE FLOW IN DROP STRUCTURE IS,F4.1,5H CFS./)
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C
C     DETERMINE SIZE OF DIKE REQD
C
  607 IF((VLREQD .LE. 2500000) .AND. (HT .GT. 5))GO TO 610
      IF((VLREQD .LE. 4200000) .AND. (HT .GT. 7.5))GO TO 620
      IF((VLREQD .LE. 80000    ) .AND. (HT .GT. 10))GO TO 630
      IF (HT .LE. 10) GO TO 610
      IF (HT .LE. 15) GO TO 620
      GO TO 630
C
C
C START AT 200 FT SIDE, 10 FT DEEP BASIN
  610 LSIDE = 190
C
  611 LSIDE = LSIDE + 1.
      VOL = ((LSIDE-50.)**2+(LSIDE-10.)**2)*.5*8
      IF  (VOL .LT. VLREQD) GO TO 611
C
C START AT 9 FT HIGH DIKES TO CATCH ALL CASES
C
      HTDIKE = 10.
  615 HTDIKE = HTDIKE - .1
      VLDIKE =  HTDIKE*(10+(2.5*HTDIKE/2)+(4*HTDIKE/2))*LSIDE*4
      VLEXC  = (((LSIDE-50)+(LSIDE-(5*HTDIKE)))/2)**2*(10-HTDIKE)
      IF ((VLDIKE - VLEXC) .LT. 0)  GO TO 640
      IF (HTDIKE .LE. 0)GO TO 640
      GO TO 615
C
C
C  START AT 400 FT SIDE, 15 FT DEEP BASIN
C
  620 LSIDE = 390
C
  621 LSIDE = LSIDE+ 1.
      VOL =  ((LSIDE-75.)**2+(LSIDE-10.)**2)*.5*13
      IF (VOL .LT. VLREQD) GO TO 621
C
C START AT 14 FT HIGH DIKES TO CATCH ALL CASES
C
      HTDIKE = 15.
  625 HTDIKE = HTDIKE -.1
      VLDIKE = HTDIKE*(15+(2.5*HTDIKE/2)+(4*HTDIKE/2))*LSIDE*4.
      VLEXC  = (((LSIDE-75)+(LSIDE-(5*HTDIKE)))/2)**2*(15-HTDIKE)
      IF  ((VLDIKE - VLEXC) .LT. 0)  GO TO 640
      IF (HTDIKE .LE. 0) GO TO 640
      GO TO 625
C
C
C     START AT 450 FT SIDE, 20 FT DEEP BASIN
C
  630 LSIDE = 440
C
  631 LSIDE = LSIDE+ 1.
      VOL = ((LSIDE-100)**2+(LSIDE-10)**2)*.5*18
      IF (VOL .LT. VLREQD) GO TO 631
C
C     START AT 19 FT HIGH DIKES TO CATCH ALL CASES
C
      HTDIKE = 20
  635 HTDIKE = HTDIKE-.1
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      VLDIKE = HTDIKE*(20+(2.5*HTDIKE/2)+(4*HTDIKE/2))*LSIDE*4.
      VLEXC  = (((LSIDE-100)+(LSIDE-(5*HTDIKE)))/2)**2*(20-HTDIKE)
      IF ((VLDIKE - VLEXC) .LT. 0)  GO TO 640
      IF (HTDIKE .LE. 0) GO TO 640
      GO TO 635
C
  640 DKVOL = ((VLEXC+VLDIKE)/2)/27
      IF (SWITCH .EQ. 1HN) PRINT 3606,LSIDE,HTDIKE,SIZE,DKVOL
 3606 FORMAT (35H  THE DIKE IS ASSUMED TO BE SQUARE,,/2X,F8.0,16H FEET O
     1N A SIDE,,F3.0,11H FEET HIGH,,/32H  WILL HAVE AN INSIDE VOLUME OF
     1,F8.0,/23H  CU. YDS. AND REQUIRE ,F8.0,12H CU. YDS. OF,/21H  EARTH
     1WORK TO BUILD.)
C
C  CALCULATE DIKING CONSTRUCTION COST
C
  650 IF ((0 .LE. DKVOL) .AND. (DKVOL .LE. 30000))
     1 PDKCST= ((.000015*DKVOL)+.75)*DKVOL
      IF ((30000 .LT. DKVOL) .AND. (DKVOL .LE. 60000))
     1 PDKCST= .3*DKVOL
      IF ((60000 .LT. DKVOL) .AND. (DKVOL .LE. 90000))
     1 PDKCST= ((.0000067*DKVOL)-.1)*DKVOL
      IF (DKVOL .GT. 90000)
     1 PDKCST= ((.0000042*DKVOL)+.12)*DKVOL
C
      IF (INTER .NE. 3HYES) GO TO 604
      PROD = PRODT
      INTER = 2HNO
      INTDKE = PDKCST + CDROP
      PDKCST = CDROP = 0
      IF (SWITCH .EQ. 1HN) PRINT 3607,INTDKE
      GO TO 601
  604 PDKCST = PDKCST + CDROP
      IF (SWITCH .EQ. 1HN) PRINT 3607,PDKCST
      PDKCST = PDKCST + INTDKE
      INTDKE = 0
      IF (SWITCH .EQ. 1HN) PRINT 3614,PDKCST
 3614 FORMAT (//63HTOTAL COST TO CONSTRUCT INTERMEDIATE DIKES AND REHAND
     1LING DIKES/5HIS $ ,F10.2)
      PDKCST = PDKCST - CDROP
      GO TO 655
C
  614 PDKCST = PDKCST + CDROP
      IF (SWITCH .EQ. 1HN) PRINT 3607,PDKCST
 3607 FORMAT (/16H  IT WILL COST $,F11.2,14H TO CONSTRUCT.)
      PDKCST = PDKCST - CDROP
C
C      . . . . . . . . . . .
C     --------------------
C      DIKING SHAPE COST .
C     --------------------
C
  655 IF ((TUR .EQ. 3HYES) .AND. (WATER .EQ. 1HN)) GO TO 656
      GO TO 660
  656 INTCIN = .20* VLREQD/27.
      IF (LSIDE .LT. 500) INTCIN = 1.15*INTCIN
      IF (SWITCH .EQ. 1HN) PRINT 3608,INTCIN
 3608 FORMAT (/51HON THE INTERMEDIATE SITES THAT ARE DIKED, THE DIKES,
     113H ARE LEVELED./13HTHIS COSTS $ ,F10.2)
  660 IF (EREQ .GE. 20) GO TO 670
      CSTCIN= .20*VLREQD/27.
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      IF (LSIDE .LT. 500) CSTCIN = 1.15 *CSTCIN
      IF (SWITCH .EQ. 1HN) PRINT 3609,CSTCIN
 3609 FORMAT (/43HTHIS SITE IS EXPECTED TO BE USED ONCE EVERY,/44H5 YEAR
     1S OR LESS. THEREFORE THE DIKES WILL BE,/22HLEVELED.  THIS COSTS $.
     1F10.2)
      GO TO 710
  670 IF (FREQ .GT. 50) GO TO 680
      CSTSHP = (LSIDE**2)*.10
      IF (LSIDE .GT. 500) CSTSHP = 1.3*CSTSHP
      IF (HTDIKE .GE. 15) CSTSHP = 1.2*CSTSHP
      IF (SWITCH .EQ. 1HN) PRINT 3610,CSTSHP
 3610 FORMAT (/43HTHIS SITE IS EXPECTED TO BE USED ONCE EVERY,/45H3-5 YE
     1ARS. THEREFORE THE DIKES MAY BE SHAPED,,/46HVEGETATED, AND MADE ST
     1ABLE UNTIL THE NEXT TIME,/33HTHE SITE IS NEEDED.  THIS COSTS $,F10
     1.2)
      GO TO 710
  680 IF (SWITCH .EQ. 1HN) PRINT 3611
 3611 FORMAT (/43HTHIS SITE WILL BE USED AT LEAST EVERY OTHER,/40HYEAR.
     1 NO COSTS OF SHAPING ARE ESTIMATED./44HEXCEPT FOR RECREATION OR ER
     1OSION PROTECTION.)
      GO TO 710
C
C       *************************
C           BERMING COSTS
C       *************************
C
 6600 IF (BERM .EQ. 1HN) GO TO 700
      IF (METHOD .EQ. 1) CSTBRM(1)=DAYS*HOURS*2*D9(1)
      IF (METHOD .EQ. 2) CSTBRM(2)=DAYS*HOURS*2*D7(1)
      IF((WATER .EQ. 1HY) .AND. ((TUB .EQ. 3HYES) .OR. (METHOD .EQ. 3)))
     1  CSTBRM(METHOD) = ULDDAY*HOURS*2*D7(1)
      GO TO 700
C
C . ..... ..... ... . ..... . . ........ ..
C --------------------------------------
C  .  AREA COMPUTATIONS AND LANDSCAPING .
C --------------------------------------
C
  700 LPILE = 190
  701 LPILE = LPILE+ 1.
      HTPILE = .025*LPILE
      IF (HTPILE .GE. HT) HTPILE = HT
      VLPILE = ((LPILE**2+    (LPILE-(A*HTPILE))**2)/2)*HTPILE
      IF (VLPILE .LE. (CUYDS*27))GO TO 701
      AREA(METHOD) = (LPILE**2)/43560
      PILE(METHOD) =HTPILE
C
      TTLVOL = CUYDS*27*50*FREQ/100
  705 LPILE = LPILE+ 1.
      HTPILE = .025*LPILE
      IF (HTPILE .GE. HT) HTPILE = HT
      VLPILE = ((LPILE**2+(LPILE-(A*HTPILE))**2)/2)*HTPILE
      IF (VLPILE .LE. TTLVOL) GO TO 705
      TTLARA = (LPILE**2)/43560
      IF (SWITCH .EQ. 1HN) PRINT 3701,AREA(METHOD),PILE(METHOD) ,TTLARA,
     1HTPILE
      AREA40(METHOD) = TTLARA
      PILE40(METHOD) = HTPILE
 3701 FORMAT (/26H  THE DISPOSAL SITE COVERS,F6.0,10H ACRES AND,,/4H  IS
     1,F3.0,34H FT. HIGH.  OVER THE 40 YEAR STUDY,/28H  PERIOD THE PILE
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     1WILL COVER ,F4.0,6H ACRES,/9H  AND BE ,F3.0,10H FT. HIGH.)
      GO TO 720
C
  710 IF (HT .LE. HTDIKE) PRINT 3705
 3705 FORMAT (52H1THE MAXIMUM HEIGHT OF DIKE THAT YOU ASSIGNED IS LESS,
     1/46HTHAN THE COMPUTED DIKE HEIGHT FOR ONE DREDGING,/37HOPERATION.
     1 PLEASE REVISE YOUR VALUE /)
      IF (HT .LE. HTDIKE) READ (30,*) HT
      LDIKE = LSIDE +20+ (8*HTDIKE)
      AREA(METHOD)  = (LDIKE**2)/43560
      PILE(METHOD) = HTDIKE
      IF (SWITCH .EQ. THN) PRINT 3702,AREA(METHOD)
 3702 FORMAT (30H  THE ENTIRE DIKED AREA COVERS,F4.0,7H ACRES.)
C
      TTLVOL =(CUYDS*27*50*FREQ/100)-(CUYDS*27)
      LPILE = LDIKE-10
  715 LPILE = LPILE+ 1
      HTPILE= .025*LPILE
      IF ((HTPILE+HTDIKE) .GE. HT) HTPILE=HT-HTDIKE
      IF(HTPILE .LT. 0) GO TO 720
      VLPILE = ((LPILE**2+(LPILE-(8*HTPILE))**2)/2)*HTPILE
C . . SECONDARY HANDLING.
C ------------------------
  800 IF(TRUCK.NE.THY)GO TO 900
C
C      COST BY TRUCK
C


      IF (DISTSH .LT. 5) CSTHL= CUYDS
      IF (DISTSH .GE. 5) CSTHL= CUYDS + (0.05*CUYDS*(DISTSH-5.0))
C
C
      IF ((FREQ .GE. 35) .AND. (CUYDS .LT. 10000)) GO TO 810
      IF ((FREQ .GE. 35) .AND. (CUYDS .GE. 10000)) GO TO 820
      IF ((20 .LE. FREQ) .AND. (FREQ .LT. 35) .AND. (CUYDS .LT. 10000))
     1     GO TO 830
      IF ((20 .LE. FREQ) .AND. (FREQ .LT. 35) .AND. (CUYDS .GE. 10000))
     1     GO TO 840
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```
      IF ((FREQ .LT. 20) .AND. (CUYDS .LT. 10000)) GO TO 850
      IF ((FREQ .LT. 20) .AND. (CUYDS .GE. 10000)) GO TO 860
      GO TO 870
C
  810 CSTRD= 1500.0 / (100.0/FREQ)
      CSTFLD= 300.0 + (0.65*CUYDS)
      CSTCNV= 0.0
      CSTSPG= 0.0
      GO TO 870
C
  820 CSTRD= 2500.0 / (100.0/FREQ)
      CSTCNV= (((135000.0*0.1032*(100.0/FREQ))+300.0)/(100.0/FREQ))
     1        + (0.60*CUYDS)
      CSTFLD= 0.0
      CSTSPG= 0.0
      GO TO 870
C
  830 CSTRD= 1500.0 / (100.0/FREQ)
      CSTFLD= 300.0 + (0.65*CUYDS)
      CSTSPG= (CUYDS/2000.0) * 1000.0
      CSTCNV= 0.0
      GO TO 870
C
  840 CSTRD= 2500.0 / (100.0/FREQ)
      CSTCNV= 1000.0 + (0.75*CUYDS)
      CSTSPG= (CUYDS/5000.0) * 1000.0
      CSTFLD= 0.0
      GO TO 870
C
  850 CSTRD= 1000.0
      CSTFLD= 300.0 + (0.65*CUYDS)
      CSTSPG= (CUYDS/2000.0) * 500.0
      CSTCNV= 0.0
      GO TO 870
C
  860 CSTRD= 1600.0
      CSTCNV= 1000.0 + (0.75*CUYDS)
      CSTSPG= (CUYDS/5000.0) * 500.0
      CSTFLD= 0.0
      GO TO 870
C
  870 CONTINUE
      CSTSH1= (0.15*CUYDS) + 500.0
C
      CSTSHD= CSTRD + CSTCNV + CSTFLD + CSTSPG + CSTHL + CSTSH1
      IF (SWITCH .EQ. 1HN) PRINT 3801,CSTSHD
 3801 FORMAT (/31H  TRUCKING THE MATERIAL COSTS $,F10.2,/10X,19H(SUBJECT
     1 TO CHANGE))
      GO TO 900
C
C ..........
C ----------
C    ECON
C ----------
C
  900 ESTCST(METHOD) = CSTDRG + CDROP + PDKCST +
     1 CSTCTN + CSTSHP + CSTSHD + DOLLR + CSTLND
      DKE(METHOD) = PDKCST + CDROP + CSTCTN + CSTSHP + CSTLND
      UNIT(METHOD) = ESTCST(METHOD)/CUYDS
C
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```
      IF (FREQ .EQ. 90)
     1     ANNCST(METHOD)= 1.02324 * FSTCST(METHOD)
      IF (FREQ .EQ. 85)
     1     ANNCST(METHOD)= 0.98024 * FSTCST(METHOD)
      IF (FREQ .EQ. 80)
     1     ANNCST(METHOD)= 0.93724 * FSTCST(METHOD)
      IF (FREQ .EQ. 75)
     1     ANNCST(METHOD)= 0.89424 * FSTCST(METHOD)
      IF (FREQ .EQ. 70)
     1     ANNCST(METHOD)= 0.85124 * FSTCST(METHOD)
      IF (FREQ .EQ. 65)
     1     ANNCST(METHOD)= 0.80823 * FSTCST(METHOD)
      IF (FREQ .EQ. 60)
     1     ANNCST(METHOD)= 0.72223 * FSTCST(METHOD)
      IF (FREQ .EQ. 55)
     1     ANNCST(METHOD)= 0.63622 * FSTCST(METHOD)
      IF (FREQ .EQ. 50)
     1     ANNCST(METHOD)= 0.55022 * FSTCST(METHOD)
      IF (FREQ .EQ. 45)
     1     ANNCST(METHOD)= 0.47964 * FSTCST(METHOD)
      IF (FREQ .EQ. 40)
     1     ANNCST(METHOD)= 0.43513 * FSTCST(METHOD)
      IF (FREQ .EQ. 35)
     1     ANNCST(METHOD)= 0.38807 * FSTCST(METHOD)
      IF (FREQ .EQ. 30)
     1     ANNCST(METHOD)= 0.33517 * FSTCST(METHOD)
      IF (FREQ .EQ. 25)
     1     ANNCST(METHOD)= 0.28527 * FSTCST(METHOD)
      IF (FREQ .EQ. 20)
     1     ANNCST(METHOD) = 0.23550 * FSTCST(METHOD)
      IF (FREQ .EQ. 15)
     1     ANNCST(METHOD)= 0.185396 * FSTCST(METHOD)
      IF (FREQ .EQ. 10)
     1     ANNCST(METHOD)= 0.137022 * FSTCST(METHOD)
      IF (FREQ .EQ. 5)
     1     ANNCST(METHOD)= 0.091660 * FSTCST(METHOD)
C
      IF (SWITCH .EQ. 1HN) PRINT 3901,FSTCST(METHOD),ANNCST(METHOD)
 3901 FORMAT (//38H  TOTAL COST OF DREDGING THE SITE IS $,F11.2,/26H  AV
     1ERAGE ANNUAL COST IS $,F11.2,///)
C
      IUB = 2HNO
      CSTCTN = PDKCST = CDROP = CSTMV = CSTLD = CSTTHM = CSTSHP =
     1CSTLND = CSTSHD = CSTDUB = CSTMUD = CSTPNE = CSTMOB = CSTHAU =
     1CSTTRP = CSTWD = CSTPD = CSTFLD = CSTCNV =CSTHL =CSTH1 =
     1CSTSPG = UNLOAD = V = Y = Z = INTCIN = 0
C
      IF (METHOD .EQ. 2) GO TO 300
      IF (METHOD .EQ. 3) GO TO 5000
C
C ********************************
C      DUBUQUE METHOD,  METHOD 2
C ********************************
C
 200  CSTDUB=0
      METHOD=2
      IF (SWITCH .EQ. 1HN) PRINT 3051,(NAME(I),I=1,5),DATE
 3051 FORMAT (//5X,5A10,7X,6HPAGE 2,/60X,A8)
      PRINT 3200
 3200 FORMAT(//20HFOR 12-INCH HYDRAULIC DREDGE /)
```

```
      LENEQV= DIST + (HGHT/0.094)
C
      IF (LENEQV .LE. 1500) GO TO 210
      IF ((1500 .LT. LENEQV) .AND. (LENEQV .LE. 1750)) GO TO 220
      IF ((1750 .LT. LENEQV) .AND. (LENEQV .LE. 3000)) GO TO 230
      IF (LENEQV .GT. 3000) GO TO 240
C
 210  HOURS=15.0-(0.0017*LENEQV)
      PROD=(330.0-(0.094*LENEQV))*HOURS
      DAYS= (CUYDS/PROD) + 1.0
      CSTDUR=DAYS*(DUBQE(1)+TD1000(1)+(2*TD380(1))+TD175(1)+ANCH(1)+
     1HOIST(1))+HOURS*DAYS*(DUBQE(3)+TD175(3)+ANCH(3)+HOIST(3))+
     1(16-HOURS)*DAYS*(TD1000(3)+2*(TD380(3)))
      IF (SWITCH .EQ. 1HN) PRINT 3032,DAYS,CSTDUR,HOURS
      GO TO 250
C
 220  HOURS=13.3-(0.00056*LENEQV)
      PROD=(330.0-(0.094*LENEQV))*HOURS
      DAYS=(CUYDS/PROD)+2.0
      CSTDUR=DAYS*(DUBQE(1)+TD1000(1)+(2*TD380(1))+TD175(1)+ANCH(1)+
     1HOIST(1))+HOURS*DAYS*(DUBQE(3)+TD175(3)+ANCH(3)+HOIST(3))+
     1(16-HOURS)*DAYS*(TD1000(3)+2*(TD380(3)))
      IF (SWITCH .EQ. 1HN) PRINT 3032,DAYS,CSTDUR,HOURS
      GO TO 250
C
 230  HOURS=13.3-(0.00056*LENEQV)
      PROD= (260.0-(0.05*LENEQV)) * HOURS
      DAYS=(CUYDS/PROD)+2.0
      CSTDUR=DAYS*(DUBQE(1)+TD1000(1)+(2*TD380(1))+TD175(1)+ANCH(1)+
     1HOIST(1))+HOURS*DAYS*(DUBQE(3)+TD175(3)+ANCH(3)+HOIST(3))+
     1(16-HOURS)*DAYS*(TD1000(3)+2*(TD380(3)))
      IF (SWITCH .EQ. 1HN) PRINT 3032,DAYS,CSTDUR,HOURS
      GO TO 250
C
 240  HOURS=12
      PROD=1760
      DAYS=(CUYDS/PROD)+1.0
      CSTDUR=DAYS*(DUBQE(1)+TD1000(1)+(2*TD380(1))+TD175(1)+ANCH(1)+
     1HOIST(1))+HOURS*DAYS*(DUBQE(3)+TD175(3)+ANCH(3)+HOIST(3))+
     1(16-HOURS)*DAYS*(TD1000(3)+2*(TD380(3)))
      TUB = 3HYES
      IF (SWITCH .EQ. 1HN) PRINT 3037,DAYS,CSTDUR,HOURS
      GO TO 750
  250 CSTDRG = CSTDUR +CSTLD + CSTMV + UNLOAD
      DAZE(METHOD) = DAYS
      GO TO 600
C
C   ****************************
C     CLAMSHELL DREDGE
C   ****************************
C
  300 METHOD = 3
      CSTMOB = HAUSER(1)+WADE(1)+(((2*TD175(1))+TD380(1)+TD1000(1))*2)
      TUB = 3HYES
      IF (SWITCH .EQ. 1HN) PRINT 3052,(NAME(I),I=1,5),DATE
 3052 FORMAT (////5X,5A10,7X,6HPAGE 3./60X,A8)
      PRINT 3301
 3301 FORMAT (//21HFOR CLAMSHELL DREDGE ./)
      IF (CUYDS .LE. 200000) CSTHAU = (2.34-(.0000042*CUYDS))*CUYDS
      IF ((200000 .LT. CUYDS) .AND. (CUYDS .LE. 400000))
```

```
     1 CSTHAU = (1.75-(.000025*CUYDS))*CUYDS
       IF (CUYDS .GT. 400000) CSTHAU = .75*CUYDS
C
C      COST TO TRANSPORT
C
C
       IF (LENMT .LE. 10)
     1CSTTRP=CUYDS*((.067*LENMT)+.33)
       IF ((10 .LT. LENMT) .AND. (LENMT .LE. 20))
     1CSTTRP=CUYDS*((.03*LENMT)+.7)
       IF (LENMT .GT. 20)
     1CSTTRP=CUYDS*((.06*LENMT)+.1)
C
C
C
C
       IF (SWITCH .EQ. 1HN) PRINT 3302,CSTHAU,CSTTRP
  3302 FORMAT (/55H  DREDGING THE RIVER AND PLACING THE MATERIAL ON BARGE
     1S./9H  COSTS $,F10.2,47H.  MOVING THE BARGES TO THE DISPOSAL SITE
     1COSTS./3H  $,F10.2,26H. (THIS VALUE MAY CHANGE).)
       GO TO 760
   310 CSTDRG = CSTMOB + CSTHAU + CSTTRP + UNLOAD
       IF (SWITCH .EQ. 1HN) PRINT 3303,CSTDRG
  3303 FORMAT (58H  THE TOTAL COST OF THE CLAMSHELL DREDGING OPERATION AL
     1ONE./6H  IS $,F10.2,42H.  THE COSTS OF LOADING THE BARGES, MOVING,
     1/69H  THE BARGES AND UNLOADING BY CLAMSHELL ARE BASED ON "PER CUBI
     1C YARD"./48H  FACTORS RATHER THAN EQUIPMENT OPERATING COSTS.)
       IF (WATER .EQ. 1HN) GO TO 350
       PRINT 3304
  3304 FORMAT (/23HIS A LOCKAGE NECESSARY?)
  9060 READ (30,3102) ANSWER
       IF (ANSWER .EQ. 1HS) GO TO 5001
       IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9059
C      PRINT (9001,9002,9003,9004,9005) TYPO
       IF (TYPO .LE. 5) TYPO = TYPO + 1
       GO TO 9060
  9059 IF (SWITCH .EQ. 1HN) PRINT 3305
  3305 FORMAT (/66H  ST PAUL DISTRICT NOW HAS 6 BARGES CAPABLE OF DUMPING
     1   1- 175 CY,/66H  HYDROCLAP, 2- 165 CY SIDE DUMP, 1-110 CY SIDE
     1DUMP & 2- 225 CY,/19H  BOTTOM DUMP SCOWS)
       IF (ANSWER .EQ. 1HY) GO TO 340
       IF (LENMT .LE. 3)  PRINT 3306
  3306 FORMAT (/27H  2 SCOWS AND 1 TENDER USED)
       IF ((3 .LT. LENMT) .AND. (LENMT .LE. 6)) PRINT 3307
  3307 FORMAT (/28H  3 SCOWS AND 2 TENDERS USED)
       IF ((6 .LT. LENMT) .AND. (LENMT .LE. 9)) PRINT 3308
  3308 FORMAT (/28H  4 SCOWS AND 3 TENDERS USED)
       IF ((9 .LT. LENMT) .AND. (LENMT .LE. 11)) PRINT 3309
  3309 FORMAT (/28H  5 SCOWS AND 4 TENDERS USED)
       IF (11 .LT. LENMT) PRINT 3310
  3310 FORMAT (/68H  MORE BOTTOM DUMPING SCOWS OR TENDERS ARE NEEDED.  TH
     1E EXACT FLEET./15H  IS NOT KNOWN.)
       GO TO 330
   340 IF (LENMT .LE. 2) PRINT 3311
  3311 FORMAT (/28H  4 SCOWS AND 3 TENDERS USED)
       IF ((2 .LT. LENMT) .AND. (LENMT .LE. 5)) PRINT 3312
  3312 FORMAT (/28H  5 SCOWS AND 4 TENDERS USED)
       IF ((5 .LT. LENMT) .AND. (LENMT .LE. 8)) PRINT 3313
  3313 FORMAT (/68H  6 SCOWS USED, 5 TENDERS NEEDED - ONE NEW TENDER MUST
     1 BE PURCHASED.)
```

```
      IF ((8 .LT. LENMT) .AND. (LENMT .LE. 10)) PRINT 3314
 3314 FORMAT (/65H  7 SCOWS AND 6 TENDERS NEEDED - ONE NEW SCOW AND TWO
     1NEW TENDERS./20H  MUST BE PURCHASED.)
      IF (10 .LT. LENMT) PRINT 3310
  330 TIME1 = CUYDS/1500
      TIME2 = CUYDS/3000
      TIME3 = CUYDS/4500
      DAZE(METHOD) = TIME2
      IF (SWITCH .EQ. 1HN) PRINT 3315,TIME1,TIME2,TIME3
 3315 FORMAT (/48HA ROUGH ESTIMATE OF DAYS TO DREDGE THIS SITE IS.,F4.1,
     116H DAYS FOR A ONE-/17HSHIFT OPERATION, ,F4.1,37H DAYS FOR A TWO-
     1SHIFT OPERATION, AND ,F4.1,9H DAYS FOR/24HA THREE-SHIFT OPERATION
     1.)
      GO TO 360
  350 PRINT 3304
 9034 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9033
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9034
 9033 IF (SWITCH .EQ. 1HN) PRINT 3316
 3316 FORMAT (/60H  ST PAUL DISTRICT NOW HAS 6 BARGES WHICH CAN BE UNLOA
     1DED BY,/66H  CLAMSHELL   1- 175 CY HYDROCLAP, 2- 225 CY BOTTOM CUM
     1P SCOWS AND,/68H  3 DECK CARGO BARGES WITH TEMPORARY TIMBER BOXES
     1HOLDING 100-110 CY,/7H  EACH.)
      IF (ANSWER .EQ. 1HY) GO TO 370
      IF (LENMT .LE. 3) PRINT 3317
 3317 FORMAT (/28H  3 SCOWS AND 2 TENDERS USED)
      IF ((3 .LT. LENMT) .AND. (LENMT .LE. 6)) PRINT 3318
 3318 FORMAT (/28H  4 SCOWS AND 2 TENDERS USED)
      IF ((6 .LT. LENMT) .AND. (LENMT .LE. 9.5)) PRINT 3319
 3319 FORMAT (/28H  5 SCOWS AND 3 TENDERS USED)
      IF ((9.5 .LT. LENMT) .AND. (LENMT .LE. 11)) PRINT 3320
 3320 FORMAT (/66H  4 TENDERS USED, 6 SCOWS NEEDED - ONE NEW SCOW MUST B
     1E PURCHASED.)
      IF (11 .LT. LENMT) PRINT 3321
 3321 FORMAT (/67H  MORE BARGES OR TENDERS ARE NEEDED. THE EXACT FLEET
     1IS NOT KNOWN.)
      GO TO 380
  370 IF (LENMT .LE. 2) PRINT 3322
 3322 FORMAT (/28H  5 SCOWS AND 3 TENDERS USED)
      IF ((2 .LT. LENMT) .AND. (LENMT .LE. 3.3)) PRINT 3323
 3323 FORMAT (/64H  6 SCOWS AND 4 TENDERS NEEDED - ONE NEW SCOW MUST BE
     1PURCHASED.)
      IF ((3.3 .LT. LENMT) .AND. (LENMT .LE. 6.2)) PRINT 3324
 3324 FORMAT (/65H  7 SCOWS AND 5 TENDERS NEEDED - TWO NEW SCOWS AND ONE
     1 NEW TENDER./20H  MUST BE PURCHASED.)
      IF ((6.2 .LT. LENMT) .AND. (LENMT .LE. 9.5)) PRINT 3325
 3325 FORMAT (/68H  8 SCOWS AND 6 TENDERS NEEDED - THREE NEW SCOWS AND T
     1WO NEW TENDERS./20H  MUST BE PURCHASED.)
      IF (9.5 .LT. LENMT) PRINT 3321
  380 TIME1 = CUYDS/1000
      TIME2 = CUYDS/2000
      DAZE(METHOD) = TIME2
      TIME3 = CUYDS/3000
      IF (SWITCH .EQ. 1HN) PRINT 3315,TIME1,TIME2,TIME3
      SLURRY(3) = 100.
  360 GO TO 700
C *************************
```

```
      OUTPUT SITE SUMMARY
C
C  ***************************
C
      PRINT 3000
 3000 FORMAT (//2X,3HXXX,2X,1HX,1X,7(1HX),1X,5(1HX),4X,4(1HX),1X,1HX,3X
     1,1HX,1X,2(1HX,4X,1HX,1X),1X,3HXXX,2X,4(1HX),2X,1HX,3X,1HX,/1X,1HX,
     1HX,1HX,4X,1HX,1X,1HX,7X,1HX,5X,1HX,3X,1HX,1X,2(2HXX,2X,2HXX,1X),1H
     1X,3X,1HX,1X,1HX,3X,1HX,2X,1HX,1X,1HX,/2X,3HXXX,3X,2(1HX,4X),3HXXX,
     1HX,3HXXX,2X,1HX,3X,1HX,1X,2(1HX,1X,2HXX,1X,1HX,1X),1HX,3X,1HX,1X,4
     1(1HX),4X,1HX,/5X,1HX,2X,1HX,2(4X,1HX),11X,1HX,1X,1HX,3X,1HX,1X,1HX
     1,1X,1HX,1X,1HX,4X,1HX,1X,5(1HX),1X,1HX,2X,1HX,4X,1HX,/1X,4(1HX),3X
     1,2(1HX,4X),5(1HX),3X,4(1HX),3X,3HXXX,2X,1HX,4X,1HX,1X,1HX,4X,1HX,1
     1X,1HX,3X,1HX,1X,1HX,3X,1HX,3X,1HX)
      PRINT 3004,(NAME(I),I=1,5),DATE
 3004 FORMAT (/10X,5A10,2X,A8,//11HCONDITIONS ,/12X,10HDREDGE CUT,20X,
     113HDISPOSAL SITE,)
      PRINT 3011,CUYDS,IDAY,FREQ,HGHT,DIST,HT
 3011 FORMAT (5X,F6.0,15H CU YDS DREDGED,14X,I1,15H DAYS RETENTION,/5X,
     1F3.0,11H FREQUENCY,21X,F3.0,18H FT ABOVE LCP ELEV,/5X,F6.0,
     120H FT TO DISPOSAL SITE,9X,F3.0,27H FT MAX DIKE OR PILE HEIGHT)
      IF ((DIKE .EQ. 1HN) .AND. (BERM .EQ. 1HN)) PRINT 3016
 3016 FORMAT (40X,20HNO DIKING OR BERMING)
      IF (DIKE .EQ. 1HY) PRINT 3017
 3017 FORMAT (40X,15HDIKING REQUIRED)
      IF (BERM .EQ. 1HY) PRINT 3018
 3018 FORMAT (40X,16HBERMING REQUIRED)
      PRINT 3012
 3012 FORMAT (/19HSPECIAL CONDITIONS,)
      IF (TRUCK .EQ. 1HY) PRINT 3013,DISTSH,TRSITE
 3013 FORMAT (5X,8HTRUCKED ,F3.0,20H MILES THROUGH SITE ,A5)
      IF (OPER .EQ. 1HY) PRINT 3014,(SPEC(I),I=1,5),DOLLR
 3014 FORMAT (5X,5A10,/5X,7HCOSTS $,F6.0)
      IF (TUB .EQ. 3HYES) PRINT 3019
 3019 FORMAT (5X,37H"BATHTUBBING" NEEDED FOR SOME METHODS)
      IF (WATER .EQ. 1HN) PRINT 3020
 3020 FORMAT (5X,45HBARGES ARE DIRECTLY UNLOADED AT DISPOSAL SITE)
      IF (WATER .EQ. 1HY) PRINT 3021
 3021 FORMAT (5X,34HMATERIAL IS REHANDLED IN THE WATER)
      PRINT 3015
 3015 FORMAT (//6HDREDGE,9X,5HTOTAL,11X,4HUNIT,7X,7HAVERAGE,
     18X,6HDIKING,/5HTYPE ,10X,4HCOST,12X,4HCOST,7X,6HANNUAL,9X,5HCOSTS,
     1/42X,4HCOST)
      PRINT 3006,ESTCST(1),UNIT(1),ANNCST(1),DKE(1),
     1ESTCST(2),UNIT(2),ANNCST(2),DKE(2)
C
 3006 FORMAT (10HHYDRAULIC /9H  20-INCH,6X,1H$,F10.2,4X,1H$,F5.2,5X,
     11H$,F9.2,4X,1H$,F8.2/9H  16-INCH/9H  12-INCH,6X,1H$,F10.2,4X,
     11H$,F5.2,5X,1H$,F9.2,4X,1H$,F8.2/8H  MUDCAT/)
C
      PRINT 3007,ESTCST(3),UNIT(3),ANNCST(3),DKE(3)
C
 3007 FORMAT (11HMECHANICAL /11H  CLAMSHELL,4X,1H$,F10.2,4X,1H$,F5.2,
     15X,1H$,F9.2,4X,1H$,F8.2/9H  LADDER-/4X,6HBUCKET//8H  PNEUMA/)
C
      PRINT 3009
 3009 FORMAT (/15X,4HDAYS,3X,6HEQUIP.,4X,12HSIZE OF DIKE,8X,
     112H40-YEAR DIKE,/15X,4HUSED,3X,6HNEEDED,2(3X,4HAREA,4X,6HHEIGHT,
     13X),)
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      PRINT 3908, DAZE(1), AREA(1), PTLE(1), AREA40(1), PTLE40(1)
     1, DAZE(2), AREA(2), PTLE(2), AREA40(2), PTLE40(2)
 3908 FORMAT (10HHYDRAULIC ,/9H  20-INCH,7X,F3.0,7X,2(6X,F3.0,
     14H A.  ,F3.0,4H FT.),/9H  16-INCH,/9H  12-INCH,7X,F3.0,7X,
     12(6X,F3.0,4H A.  ,F3.0,4H FT.),/8H  MUDCAT,/)
      PRINT 3910, DAZE(3), AREA(3), PTLE(3), AREA40(3), PTLE40(3)
 3910 FORMAT (11HMECHANICAL ,/11H  CLAMSHELL,5X,F3.0,7X,2(6X,F3.0,
     14H A.  ,F3.0,4H FT.),/9H  LADDER-,/4X,6HBUCKET,//8H  PNEUMA)
 5001 PRINT 3201
 3201 FORMAT (///////20HDO YOU WANT TO STOP?)
      READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HY ) GO TO 1400
      PRINT 3202
 3202 FORMAT (/27HDO YOU WANT TO CHANGE INPUT,/24HAND TRY THIS SITE AGAI
     1N?)
 9036 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9035
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9036
 9035 IF (ANSWER .EQ. 1HY) GO TO 1000
      PRINT 3203
 3203 FORMAT (//25HENTER DATA FOR NEXT SITE.////)
      GO TO 10
 1000 PRINT 3204
 3204 FORMAT (35HWHICH VALUES DO YOU WANT TO CHANGE?,/10X,18H(ANSWER YES
     1 OR NO),/17H  RETENTION TIME?)
 9038 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9037
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9038
 9037 IF (ANSWER .EQ. 1HN) GO TO 1010
      PRINT 3205
 3205 FORMAT (/13H  NEW VALUE )
      READ (30,*) TDAY
 1010 PRINT 3013
 9040 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9039
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9040
 9039 IF (ANSWER .EQ. 1HN) GO TO 1012
      PRINT 3205
      READ (30,*) CUYDS
 1012 PRINT 3206
 3206 FORMAT (/31H  HEIGHT OF DISPOSAL SITE ABOVE,/29H  LOW CONTROL POOL
     1 ELEVATION?)
 9042 READ (30,3102)ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9041
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9042
 9041 IF (ANSWER .EQ. 1HN) GO TO 1014
      PRINT 3205
      READ (30,*) HGHT
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 1014 PRINT 3207
 3207 FORMAT (/20H NEED FOR DIKING OR BERMING?)
 9062 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9061
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9062
 9061 IF (ANSWER .EQ. 1HN) GO TO 1016
      PRINT 3017
 9044 READ (30,3102) DIKE
      IF (DIKE .EQ. 1HS) GO TO 5001
      IF ((DIKE .EQ. 1HY) .OR. (DIKE .EQ. 1HN)) GO TO 9043
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9044
 9043 IF (DIKE .EQ. 1HY) GO TO 1016
      PRINT 3018
 9045 READ (30,3102) BERM
      IF (BERM .EQ. 1HS) GO TO 5001
      IF ((BERM .EQ. 1HY) .OR. (BERM .EQ. 1HN)) GO TO 1016
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9045
 1016 PRINT 3208
 3208 FORMAT (/24H ALLOWABLE DIKE HEIGHT?)
 9047 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9046
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9047
 9046 IF (ANSWER .EQ. 1HN) GO TO 1018
      PRINT 3205
      READ (30,*) HT
 1018 PRINT 3209
 3209 FORMAT (/21H NEED FOR RESHAPING?)
 9049 READ (30,3102) ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9048
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9049
 9048 IF (ANSWER .EQ. 1HN) GO TO 1020
      PRINT 3020
 9050 READ (30,3102) LAND
      IF (LAND .EQ. 1HS) GO TO 5001
      IF ((LAND .EQ. 1HY) .OR. (LAND .EQ. 1HN)) GO TO 1020
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9050
 1020 PRINT 3210
 3210 FORMAT (/20H NEED FOR TRUCKING?)
 9052 READ (30,3102)ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9051
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9052
 9051 IF (ANSWER .EQ. 1HN) GO TO 1022
```

```
      PRINT 3021
 9054 READ (30,3102) TRUCK
      IF (TRUCK .EQ. 1HS) GO TO 5001
      IF ((TRUCK .EQ. 1HY) .OR. (TRUCK .EQ. 1HN)) GO TO 9053
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9054
 9053 IF (TRUCK .EQ. 1HN) GO TO 1022
      PRINT 3022
      READ (30,*) DISTSH
 1022 PRINT 3211
 3211 FORMAT (/23H  SPECIAL CONSTRUCTION?)
 9056 READ (30,3102)ANSWER
      IF (ANSWER .EQ. 1HS) GO TO 5001
      IF ((ANSWER .EQ. 1HY) .OR. (ANSWER .EQ. 1HN)) GO TO 9055
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9056
 9055 IF (ANSWER .EQ. 1HN) GO TO 25
      PRINT 3023
 9058 READ (30,3102) PREP
      IF (PREP .EQ. 1HS) GO TO 5001
      IF ((PREP .EQ. 1HY) .OR. (PREP .EQ. 1HN)) GO TO 9057
C     PRINT (9001,9002,9003,9004,9005) TYPO
      IF (TYPO .LE. 5) TYPO = TYPO + 1
      GO TO 9058
 9057 IF (PREP .EQ. 1HN) GO TO 25
      PRINT 3024
      READ (30,*) BOILR
      GO TO 25
 9001 FORMAT (14HWHOOPS! TRY AGAIN.)
 9002 FORMAT (33HWATCH IT!  BETTER GIVE IT ANOTHER TRY.)
 9003 FORMAT (44HOK BUTTERFINGERS!  THREE TIMES AND YOU'RE OUT!)
 9004 FORMAT (47HDOGGONE IT!  WOULD YOU WATCH WHAT YOU'RE DOING!)
 9005 FORMAT (22HI GIVE UP!  TRY AGAIN.)
 1900 CALL EXIT
      END
```

NEW EQUIPMENT

The cost data generated by use of the program described in the previous section were the only dredging cost data used in selection of placement sites for the material placement plans. It was discovered that information developed by the MENWG late in the study on dredging costs by clamshell, backhoe, and bucket-chain dredges could be adjusted to parallel the costs generated by the plan formulation level cost estimating program. These adjusted costs were developed and are shown on the pool summary sheets in the Channel Maintenance Appendix.

Dredging cost rates for plant operations (see Attachment 3) were prepared for bucket-chain and hydraulic backhoe dredges as part of the plan evaluation level cost estimating program. Preliminary computations done while the plan evaluation program was being prepared showed that either of these two dredge types may have economic as well as other advantages for implementing GREAT's selected plan. The decision was made to prepare a simple time and movement program for various combinations of barge loading (dredging) and unloading equipment and various combinations of towing configurations and developing these costs with plan formulation level wage and cost data. The equipment components and costs for each component used in this exercise are shown on the Exhibits

The operational assumptions were that:

1. While operating, a clamshell (the Hauser) would load a 175-cubic yard barge in minutes, a hydraulic backhoe in minutes, and a bucket-chain dredge in 20 minutes.

2. It takes 2 minutes to exchange an unloaded tow for a loaded tow.

3. All costs assumed 15 hours of productive work per day.

[illegible]

5. All barges are assumed to have a 175-cubic yard capacity and all tenders are 1,000 hp.

6. The only barge configurations in this exercise were 1-, 2-, and 4-barge tows.

7. The average speed for a 1-barge tow was 460 feet per minute; for a 2-barge tow, 440 feet per minute; and for a 4-barge tow, 400 feet per minute.

8. Each lockage took 25 minutes.

The following tables present cost estimates for hydraulic backhoe and ladder-bucket dredges.

Plan Formulation level dredging cost rates for plant operations

Ladder-bucket dredge, 600-hp, 24-hour operation, actual dredging operation

6

[illegible]	
1 Superintendent	2,000
1 Captain	1,900
Chief [illegible]	
Civil Engineer	
1 Office Personnel	1,000
1 Chief Surveyor	1,100
1 Surveyor	900
1 Inspector	1,000
Subtotal	7,900
Taxes, insurance and fringes (26 %)	2,050
Total	9,950 (1)

PAYROLL (Operations, Dredging)

	Hourly rate
3 Leverman	$ 5.40
3 Watch Engineers, Strikers	5.90
3 Dredge Mates	5.20
Equipment Operators - Tender	
Equipment Operators - [illegible]	
1 Welders	5.75
3 Oilers	4.60
6 Deckhands	4.20
Stewards	
Mess Attendants	
General Dump Foreman	
Dump Foreman	
Yard and Shoreman	
Other	
19 Subtotal	94.25
Work 54 hours week, Pay 64 hours week	6,032
Monthly wages (4.34 weeks)	26,180
Taxes, insurance and fringes (21 %)	5,400 (2)
Total	31,580

PAYROLL (Operations, Transit)

	Hourly rate
Watch Engineers	
Pilot	
Dredge Mates	
Tender Masters	
Tender Operators	
Tender Mates	
Deckhands	
Stewards	
Mess Attendants	
Yard and Shoremen	
Subtotal	
Work week ___ Hours Pay	
Monthly wages (4.34 weeks)	
Taxes, insurance and fringes (___ %)	
Total	0 (3)

Ladder-bucket	$3,256,700	50	10,860
1 [illegible]	130,000	50	430
1 [illegible]	63,000	40	260
1 [illegible]	140,000	40	580
1	15,000	40	60
1 Swing anchor barges	10,000	40	40
1 [illegible]	8,000	40	30
1 Survey launch	280,000	40	1,170
2 Skiff and [illegible]	3,000	4	250
Hoist			
Ferry			
Bulldozers			
Pickup trucks			
Office barge			
Tractor-trailer			
Pipeline [illegible] costs from Part III	3,908,700		13,680 (4)
Total depreciation			

OTHER OWNERSHIP COSTS

Interest on investment 11 %	$71,700	
Yard cost	15,510	
Insurance	4,300	
Season mobilization	10,440	
Lay up (6 months)	880	
Supplies, hardware	50,340	
Repair and [illegible]	3,670	
Total other ownership costs		$156,840 (5)

OTHER OPERATING COSTS

Fuel Cost: 315 hours month X 1,200 H.P. X .067 gallon/hour H.P. X 0.65 gallon =	$16,500	
Water and lubricants	1,500	
Pipeline [illegible] costs from Part III		
Supplies, subsistance	17,300	
Total other operating costs		$35,300 (6)

PART III

PIPELINE COSTS

Floating line			
Shoreline			
Total			0

26 working days per month. Enter monthly costs divided [illegible]

PART IV

DATA INPUT

Variable

383 1215 0 326 6032 1358

Hydrauli[illegible] backhoe, 800-hp, dredging operation only

$[illegible] $[illegible]

Total 9,950

	Hourly rate
2 Backhoe operators	$ 5.40
___ [illegible]	
3 Dredge [illegible]	5.20
3 [illegible]	5.20
___ [illegible]	
___ [illegible]	
___ Oilers	
6 [illegible]	4.20
___ Stewards	
___ Mess Attendants	
___ General [illegible] Foreman	
___ Dump [illegible]	
___ Yard and Shoremen	
___ Other	
Subtotal	72.60
Work 54 hours per week; Pay 64 hours per week	4,646
Monthly wages (4.34 weeks)	20,160
Taxes, insurance and fringes (21 %)	4,230
Total	24,400

Pipeline [illegible] costs from Part III 1,582,000

$[illegible]

OTHER [illegible]

Interest on investment 11 %	$29,000	
[illegible]	8,[illegible]	
Insurance	2,000	
[illegible]	1,880	
[illegible]	[illegible]	
Supplies, hardware	23,[illegible]	
Repair [illegible]	2,000	
Total other [illegible]		$[illegible]

OTHER OPERATING COSTS

Fuel cost: 313 hours per month; 1,200 [illegible]; 0.67 gallon per hour [illegible]; 0.65 per gallon	$16,460	
Water and lubricants	300	
Pipeline (50% of pipeline costs from Part III)		
Supplies, subsistance	13,650	
Total other operating costs		$30,410(6)

PAYROLL (Operations, Transit)

	Hourly rate
___ Watch Engineers	$
___ Pilot	
___ Dredge Mates	
___ Tender Masters	
___ Tender Operators	
___ Tender Mates	
___ Deckhands	
___ Stewards	
___ Mess Attendants	
___ Yard and Shoremen	
Subtotal	
Work ___ Hours Pay week	
Monthly wages (4.34 weeks)	
Taxes, insurance and fringes (___%)	
Total	16,340

PART III

PIPELINE COSTS

	Max	Sm	Rqd
Floating line	$	$	
Shoreline			
Total			

Note: Assume ___ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUT

12-inch hydraulic dredge, in-water rehandling

[illegible]

[illegible]

____Project Manager

____Superintendent ____

____Captain ____

____Chief Engineer ____

____Civil Engineer ____

____Office Personnel ____

____Chief Surveyor ____

____Surveyor ____

____Inspector ____

Subtotal ____

Taxes, insurance and fringes (____%) ____

Total ____ (1)

PAYROLL (Operations, Dredging) — Hourly rate

____Leverman $____

____Watch Engineers, Strikers ____

____Dredge Mates ____

____Equipment Operators - Tender ____

____Equipment Operators - On land ____

____Welders ____

____Oilers. ____

____Deckhands. ____

____Stewards ____

____Mess Attendants ____

____General Dump Foreman ____

____Dump Foreman ____

____Yard and Shoreman ____

____Other ________ ____

Subtotal ____

Work____hours/week ____

Pay____hours/week ____

Monthly wages (4.34 weeks ____

Taxes, insurance and fringes (____%) ____ (2)

Total $48,410

PAYROLL (Operations, Transit) — Hourly rate

____Watch Engineers $____

____Pilot ____

____Dredge Mates ____

____Tender Masters ____

____Tender Operators ____

____Tender Mates ____

____Deckhands ____

____Stewards ____

____Mess Attendants ____

____Yard and Shoremen ____

Subtotal ____

Work____Hours Pay week ____

Monthly wages (4.34 weeks ____

Taxes, insurance and fringes (____%) ____

Total ____ (3)

Booster [illegible]

____ 1,000 [illegible]

____ [illegible]

____ [illegible]

____ Work Barges

____ Equipment [illegible]

[illegible]

____Self-propelled [illegible] barges ____

____Crew launch ____

____Survey launch ____

____Skiff and outboard ____

____Hoist (____T.) ____

____Derrick (____T.) ____

____Bulldozers ____

____Pickup trucks ____

____Office barge (trailer) ____

____Tractor/trailer ____

Pipeline (50% of pipeline costs from Part III)

Total depreciation $12,580(4)

OTHER OWNERSHIP COSTS

Interest on investment (____%) $____ month

Yard cost ____

Insurance ____

Season mobilization ____

Lay up (____month year) ____

Supplies, hardware ____

Repair and dry docking ____

Total other ownership costs $114,420(5)

OTHER OPERATING COSTS

Fuel Cost

____hours/month X

____H.P. X

____gallon/hour/H.P. X

$____/gallon = $____/month

Water and lubricants ____

Pipeline (50% of pipeline costs from Part III) ____

Supplies, subsistance ____

Total other operating costs $63,930(6)

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$____	$____	____
Shoreline		____	____
Total			

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)		1,862		484	4401	2459		

Hydraulic Backhoe, 800 hp, unloading ...

Civil Engineer

Office Personnel

Chief Surveyor

Surveyor

Inspector

Subtotal

Taxes, insurance and fringes (____%)

Total 0 (1)

PAYROLL (Operations, Dredging) Hourly rate

3 Leverman

Watch Engineers, Strikers

3 Dredge Mates

3 Equipment Operators - Tender

6 Equipment Operators - on land

Welders

Oilers

6 Deckhands

Stewards

Mess Attendants

General Dump Foreman

3 Dump Foreman

6 Yard and Shoreman

Other

Subtotal

Work ____ hours/week

Pay ____ hours/week

Monthly wages (4.34 weeks)

Taxes, insurance and fringes (____%)

Total 49,020 (2)

PAYROLL (Operations, Transit) Hourly rate

Watch Engineers

Pilot

Dredge Mates

Tender Masters

Tender Operators

Tender Mates

Deckhands

Stewards

Mess Attendants

Yard and Shoremen

Subtotal

Work ____ Hours Pay week

Monthly wages (4.34 weeks)

Taxes, insurance and fringes (____%)

Total (3)

Skiff and ...

Hoist

Derrick

Bulldozers

Pick-up trucks

Office barge, trailer

Tractor-trailer

Pipeline ... costs from Part III

$7,020

OTHER OWNERSHIP COSTS

Interest on investment	$33,200	
Yard cost	$,790	
Insurance	4,000	
Season ...	3,770	
Lay up	,600	
Supplies, hardware	22,040	
Repair and dry docking	2,060	
Total other ownership costs		$73,460

OTHER OPERATING COSTS

Fuel Cost

____ hours month

1,500 H.P.

____ gallon ...

$____ gallon

	$20,170	
Water and lubricants	900	
Pipeline ... costs from Part III		
Supplies, subsistence	27,300	
Total other operating costs		$48,...

PART III

PIPELINE COSTS

Floating line

Shoreline

Total

Note: Assumes ... working days per month. ... costs divided by working days ...

PART IV

DATA INPUT

Variable

DREDGE ... 1885 27 2825

Hydraulic backhoe, 250 hp, dredging operation only

PART I

Engineering and Office Personnel	Monthly rate
____ Project Manager	$ ____
____ Superintendent	____
____ Captain	____
____ Chief Engineer	____
____ Civil Engineer	____
____ Office Personnel	____
____ Chief Surveyor	____
____ Surveyor	____
____ Inspector	____
Subtotal	____
Taxes, insurance and fringes (____%)	____
Total	~~$9,950~~ (1)

PAYROLL (Operations, Dredging)	Hourly rate
____ Leverman	$ ____
____ Watch Engineers, Strikers	____
____ Dredge Mates	____
____ Equipment Operators - Tender	____
____ Equipment Operators - On ...	____
____ Welders	____
____ Oilers	____
____ Deckhands	____
____ Stewards	____
____ Mess Attendants	____
____ General Dump Foreman	____
____ Dump Foreman	____
____ Yard and Shoreman	____
____ Other ____	____
Subtotal	____
Work ____ hours/week	____
Pay ____ hours/week	____
Monthly wages (4.34 weeks)	
Taxes, insurance and fringes (____%)	24,400 (2)
Total	____

PAYROLL (Operations, Transit)	Hourly rate
____ Watch Engineers	$ ____
____ Pilot	____
____ Dredge Mates	____
____ Tender Masters	____
____ Tender Operators	____
____ Tender Mates	____
____ Deckhands	____
____ Stewards	____
____ Mess Attendants	____
____ Yard and Shoremen	____
Subtotal	____
Work ____ Hours Pay ____ week	____
Monthly wages (4.34 weeks)	____
Taxes, insurance and fringes (____%)	____
Total	____ (3)

PART II

Ownership and Depreciation Cost		Life (years)	Monthly costs
Dredge	$600,000		~~2,000~~
Booster pumps			
____ 1,000 H.P.			
____ 400 H.P.	130,000		~~430~~
____ 200 H.P. Tenders			
____ Work barges	63,000		260
____ Equipment ...			
____	15,000		60
____ ... Barges			
____ Crew ...	~~8,000~~		~~30~~
____ Survey launch			
2 Skiff and outboard @	~~3,000~~		250
____ Hoist (____)			
____ Derrick (____)			
____ Bulldozers			
____ Pickup trucks			
1 Office barge (trailer)	5,000		140
____ Tractor trailer			
Pipeline (50% of pipeline costs from Part III)	827,000		
Total depreciation			3,170(4)

OTHER OWNERSHIP COSTS

Interest on investment (____%)	$15,160 month	
Yard cost	6,840	
Insurance	2,000	
Season mobilization	~~1,880~~	
Lay up (____ month year)	500	
Supplies, hardware	19,730	
Repair and dry docking	1,760	
Total other ownership costs		$47,870

OTHER OPERATING COSTS

Fuel Cost		
____ hours/month X		
600 H.P. X		
____ gallon/hour/H.P. X		
$ ____ /gallon =	$8,230 month	
Water and lubricants	300	
Pipeline (50% of pipeline costs from Part III)		
Supplies, subsistance	13,650	
Total other operating costs		$22,180

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$ ____	$ ____	$ ____
Shoreline		____	____
Total			

... per month. Enter monthly costs divided ...

PART IV

DATA ...

	383	938	122 1842	853

C-37

Hydraulic backhoe, 250 hp, unloading barges

___ Project Manager		
___ Superintendent		
___ Captain		
___ Chief Engineer		
___ Civil Engineer		
___ Office Personnel		
___ Chief Surveyor	(Included	
___ Surveyor	on	
___ Inspector	dredge)	
Subtotal		
Taxes, insurance and fringes (___%)		
Total		

PAYROLL (Operations, Dredging)		Hourly rate
___ Derrick operator		
___ Watch Engineers, Strikers		
___ Dredge Mates		
___ Equipment Operators		
___ Equipment Operators		
___ Welders		
___ Oilers		
___ Deckhands	Same as	
___ Stewards	800-hp	
___ Mess Attendants	backhoe	
___ General Dump Foreman		
___ Dump Foreman		
___ Yard and Shoreman		
___ Other ___		
Subtotal		
Work ___ hours week		
Pay ___ hours week		
Monthly wages 4.34 weeks		
Taxes, insurance and fringes (___%)		
Total		$49,020

PAYROLL (Operations, Transit)	Hourly rate
___ Watch Engineers	
___ Pilot	
___ Dredge Mates	
___ Tender Masters	
___ Tender Operators	
___ Tender Mates	
___ Deckhands	
___ Stewards	
___ Mess Attendants	
___ Yard and Shoremen	
Subtotal	
Work ___ Hours Pay week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (___%)	
Total	26,640* (3)

*Use 1 crew from Section (2)

backhoe	$600,000		[illegible]
1	130,000		430
1	53,000		260
1	140,000		580
1	15,000		50
1	3,000		10
2	[illegible]		[illegible]
2 130 hp	43,000		750
1	3,000		[illegible]
	[illegible]		4,100

	11	11,[illegible]	
		[illegible]	
		[illegible]	
		4,770	
		[illegible]00	
		19,730	
		2,760	
			45,600

OTHER OPERATING COSTS

315
950
067
$0.65 — 13,030 month
Water and lubricants — 300
Pipeline —
Supplies, subsistance — 27,300
Total other operating costs — 40,630

PART III

PIPELINE COSTS

Floating line			
Shoreline			
Total			

Note: Assume working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	(1)	(2)	(3)			
OPERATION METHOD	0	1885	173	1753	1563	

TYPICAL OUTPUT

Examples of typical output from the plan formulation level cost estimating program are shown in Attachment 6.

Output is available in two forms - site summary only and site summary plus detailed description. Examples of each are shown.

SHORTCOMINGS

The major shortcoming of the plan formulation level cost estimating program was within the structure of the program itself. Many intertwined logic steps made editing and updating of the program extremely difficult. This shortcoming in and of itself led to the demise of the program as a useful tool beyond the plan formulation level.

Within the structure of the program, cost rates and component equipment could not be changed. For example, adding tenders to one of the hydraulic plants called for thorough reediting of the data, the computational functions, and the tracking logic within the program.

A further complication was the fact that rising ownership and fuel costs and wage rates were not included as part of any cost functions except to the extent that they were included in the quoted rates from AGC's "Blue Book."

STORAGE OF DATA AND COMPUTATIONS

The complete file of output from the plan formulation steps is filed at the offices of the St. Paul District, Corps of Engineers.

ATTACHMENT 3

ESTIMATE FOR DREDGING WITH
BUCKET-CHAIN AND HYDRAULIC BACKHOE DREDGES

ATTACHMENT 3

ESTIMATE FOR DREDGING WITH

BUCKET-CHAIN AND HYDRAULIC BACKHOE DREDGES

TABLE OF CONTENTS

TABLES

ATTACHMENT 3

ESTIMATE FOR DREDGING WITH BUCKET-CHAIN AND HYDRAULIC BACKHOE DREDGES

BUCKET-CHAIN DREDGE

Introduction

Several factors are involved in estimating dredging costs. Primary among these are the productivity of the unit and initial price of the equipment. Productivity determines the amount of time a plant will be on the job site and purchase price is a good indicator of repair costs, operating costs, and fuel uses. Once a piece of equipment is selected, the necessary crew can be determined to accomplish the desired production rate.

In the case of the bucket-chain dredge, the desired productivity was fairly easily determined. From field experience with the Dredge W. A. Thompson, the Derrickbarge Hauser, and the tenders Lyon and Butler, a desired minimal production rate of 600 cubic yards per hour was selected. This rate appears to be adequate for dredging fast developing shoals in the GREAT I area while avoiding use of an oversized dredge at other sites.

Largely unsuccessful efforts were made to have construction price estimates prepared by firms involved in dredge manufacturing. To fill this void, a highly subjective estimate was prepared by the work group (see the table on page 3-5). Based on this estimate and advice on dredge operation from Mr. Helmut Neuer of DWE, Deggendorf, West Germany, estimates for dredging the 9-foot channel project following the GREAT I plan were prepared.

Investment Cost Estimate

The table on page 3-5 documents in detail the cost estimate prepared for a bucket-chain dredge. Without confirmation from more authoritative sources or detailed investigation, the totals shown should be used with caution. To help the reader assess the use of this information and its validity, the assumptions made and some sources of information follow:

1. Hull. - As a starting point, several prices on barges, mostly deck barges recently purchased by St. Paul District, were compared. A 110- by 26- by 6-foot deck barge purchased in 1976 at $137,000 was selected as a representative. This price was updated to 1978 and adjusted to the 150- by 60- by 8-foot dimensions selected for the dredge. Fabrication of the ladder well was estimated to increase the cost 50 percent and the ladder support superstructure increased the cost an additional 50 percent.

2. Main Engine. - A similar dredge (mechanically) to the "Veli" was assumed. In this case a 600-hp main engine was chosen at $13,000 delivered. These costs assume all power requirements (except electrical) will be provided hydraulically from this one main engine. The dredge will not be self-propelled. All power requirements other than the main dredging machinery will be electrically powered from an on-board generator itemized elsewhere.

3. Hydraulic Power System. - The hydraulic system is powered through one 600-hp rated hydraulic system pump. The bucket chain will be powered by two hydraulic motors, each rated at 250 hp mounted at the upper end of the ladder. Four swing winches will be mounted on the deck, one on each corner, each powered by a 15-hp hydraulic motor. Cables from the winches will be fed from booms extending 8 to 12 feet

below the surface of the water, allowing the barges and shuttle tenders to approach without fear of snagging. A traction winch mounted on the bow and a hoisting winch (tabulated elsewhere) will also be hydraulically powered. Costs of hydraulic lines, cable, anchors, etc., associated with the hydraulic system and winches are not expected to exceed 20 percent of the itemized hydraulic system components.

4. Bucket-Chain and Ladder. - The buckets shown on existing bucket-chain dredges appear similar to backhoe buckets with interchangeable teeth. One-half-cubic yard backhoe buckets list for $3,000 each in 1978 catalogs. The chain is a machine-gear chain fitted to the forged and machined drive and idler pulleys. The pulleys are assumed to be 24 inches in diameter and at least 4 inches thick. The ladder is assumed to be a truss roughly equivalent to two 24-inch-wide flange beams. Rollers will be spaced 1 foot apart at the top and bottom of the ladder. The digging end of the ladder is supported and controlled by winch and hydraulic motor mounted on a frame forward of the bow. Accessories and specialized equipment mounts are not expected to exceed 15 percent of the basic ladder, bucket, and chain costs.

5. Side Casting Conveyor. - Local suppliers in the Twin Cities area felt that a 70-foot conveyor belt system with a 3-foot-wide belt would adequately handle the dredged material at this capacity. A unit, including motor, lists for about $30,000.

6. Superstructure. - The cabin includes minimal galley provisions, dredgemaster's office, engine room housing, and other crew support facilities. The shop facilities would be housed in the cabin structure and include a reasonably complete machine shop. The pilothouse and flying bridge house all operating controls and the remote navigation controls described elsewhere. Masts and antennae are self-explanatory.

7. <u>Electric and Automatic Control Systems.</u> - All electrical power on the dredge is supplied by a 100-kw generating system powered by a 100-hp engine. In addition to the standard wiring and navigation aids (lights, radar, etc.), three control systems were included. First is an automated ladder control system which would control depth of digging, speed of chain, and the swing of the vessel by controlling the swing winches. This system is combined with an automated vessel positioning system (for initially positioning the dredge in the channel) which is itemized as the vessel positioning control.

A steerage remote control system is provided so that a 1,000-hp or larger tender can be lashed to the dredge for transport and be piloted from the bridge of the dredge. It is felt that the superstructure of the dredge would seriously impair the visibility from the tender.

8. <u>Cost Summary.</u> - Accessories and outfitting of the dredge are not expected to exceed 15 percent of the construction cost of the dredge. A 20-percent allowance was made for contingencies and omissions in this cost estimate. Design of the dredge is not expected to exceed 15 percent of the construction cost. Factors for sea trials and transportation to St. Paul District were included.

Hull		[illegible]						
1976 price ([illegible])								
(110x26x6 feet)		[illegible]						
1978 price ([illegible])		[illegible]				$126,[illegible]		
Adjust for size		665,[illegible] ([illegible]x60x8 feet)				[illegible]58,[illegible] (110x26x6 feet)		
Fabrication of well for ladder		997,[illegible] ([illegible]-percent increase)				237,[illegible] (50-percent increase)		
Fabrication of ladder support structure		1,496,3[illegible] ([illegible]-percent increase)				356,600 (5[illegible]-percent increase)		
Subtotal for hull				$1,496,300				[illegible]
Basic engine	[illegible]	13,000	1	13,000	[illegible]	7,[illegible]	1	7,000
Installation	[illegible]	2,000	1	2,000	[illegible]	2,[illegible]	1	2,000
Hydraulic system								
Pump	Each	10,000	1	10,000	Each	6,000	1	6,000
Installation	Job	1,000	1	1,000	Job	500	1	500
Ladder drive motors	Each	3,000	2	6,000	Each	1,000	2	2,000
Installation	Job	1,500	1	1,500	Job	700	1	700
Swing winch	Each	20,000	4	80,000	Each	16,000	4	64,000
Swing winch motor	Each	1,000	4	4,000	Each	800	4	3,200
Installation	Each	1,000	4	4,000	Each	1,000	4	4,000
Traction winch	Each	5,000	1	5,000	Each	4,000	1	4,000
Traction winch motor	Each	500	1	500	Each	500	1	500
Lines and miscellaneous (20 percent)	Lump sum	6,000	1	6,000	Lump sum	3,800	1	3,800
Subtotal for engine and hydraulic system				133,000				97,700
Bucket chain and ladder								
Buckets	Each (1 [illegible] CY)	3,000	30	90,000	Each ([illegible] CY)	2,000	30	60,000
Chain	Each	10,000	2	20,000	Each	6,000	2	12,000
Ladder	LF	450	50	22,500	LF	350	40	14,000
Drive and idler pulleys	Each	1,500	4	6,000	Each	650	4	2,600
Bow frame ladder derrick	Lump sum	10,000	1	10,000	Lump sum	7,000	1	7,000
Ladder winch	Each	7,000	1	7,000	Each	4,000	1	4,000
Ladder winch motor	Each	2,000	1	2,000	Each	1,600	1	1,600
Chair rollers	Each	200	100	20,000	Each	150	80	12,000
Accessories (15 percent)	Lump sum	26,000	1	26,000	Each	16,600	1	16,600
Subtotal for bucket-chain and ladder				203,500				129,800
Side-casting conveyer	Lump sum	30,000	1	30,000	Lump sum	16,000	1	16,000
Superstructure (other than ladder supports)								
Cabin	Lump sum	20,000	1	20,000	Lump sum	5,000	1	5,000
Shop facilities	Lump sum	20,000	1	20,000	Lump sum	3,000	1	3,000
Pilot house and flying bridge	Lump sum	7,000	1	7,000	Lump sum	2,000	1	2,000
Masts and antenna	Lump sum	15,000	1	15,000	Lump sum	2,000	1	2,000
Total superstructure				62,000				12,000
Electric and automatic control systems								
Electrical generator	Each	16,000	1	16,000	Each	6,000	1	6,000
Wiring and navigation aids	Lump sum	8,000	1	8,000	Lump sum	3,000	1	3,000
Vessel positioning control	Lump sum	100,000	1	100,000	Lump sum	80,000	1	80,000
Steerage remote control	Lump sum	20,000		20,000	Lump sum	20,000	1	20,000
Subtotal electric and automatic systems				144,000				109,000
Cost summary								
Hull				1,496,300				356,600
Engine and hydraulic system				133,000				97,700
Bucket chain and ladder				203,500				129,800
Conveyor				30,000				16,000
Superstructure				62,000				12,000
Electric and automatic systems				144,000				109,000
Accessories and outfitting (15 percent)				310,200				110,000
Construction costs				2,379,000				845,100
Sea trials (15 days)				15,000				10,000
Contingencies in construction (20 percent)				475,800				169,000
Design (15 percent)				356,900				126,700
Transportation				30,000				20,000
Total cost				3,256,700				1,170,800

(1) Preliminary estimate based on evaluation of component dredge assemblies.

250-CUBIC YARD BUCKET-CHAIN DREDGE

Estimates were also made for a similar dredge of reduced capacity. The assumptions used for the 600-cubic yard machine basically apply here also.

BACKHOE DREDGE

Similar price estimates were prepared for a companion to the bucket-chain dredge for unloading the barges at the placement site. Although designed as an unloading device it is referred to as a dredge because the unit with support plant can easily function as a dredge. This estimate is shown in detail on the table on page 3-8. The approach used in developing this estimate was identical to the bucket-chain dredge estimate. Assumptions made were:

1. Hull. - Same process as for bucket-chain dredge. No special fabrication is needed.

2. Hydraulic Backhoe. - A 750-hp machine was selected. The list price for a semiautomated track-mounted rig was used. Basic attachments were boom and dipper for a 40-foot digging depth and 60-foot reach at grade level. Medium duty equipment would be a 6 1/4-cubic yard (PCSA-heaped) bucket and has approximately an hourly capacity of 650 cubic yards digging in sand and gravel (50-minute hour, 83-percent job efficiency, 20-foot maximum depth of cut, 60° swing loading onto trucks). This unit also is available with a 9-cubic-yard light duty bucket. Installation on the deck is assumed to be 5 percent of the list price of the backhoe.

3. Spuds and Anchors. - The dredge has three spuds each 50 feet long, fitted with adjustable collars which attach the spuds to hydraulic rams. A pair of rams raises and lowers each spud.

4. Electric and Automatic Control Systems. - Similar but less sophisticated systems are provided. No remote steering is needed because visibility is not impaired by the dredge.

5. Superstructure. - No cabin, shop, or pilothouse facilities are provided. They are not needed when the backhoe dredge is part of a bucket-chain floating plant. If costs of using the backhoe as a dredge are being prepared, an office barge and shop barge must be added to the plant.

6. Cost summary. - Similar arguments to those presented in the bucket-chain discussion hold true here.

250-CUBIC YARD BACKHOE DREDGE

As in the case of the bucket-chain dredge, a smaller version of the backhoe was also evaluated. The machine chosen was very similar to the larger unit. It is a 375-hp machine with the same basic attachments and has a 35-foot maximum digging depth and a 50-foot reach at grade level. Medium duty equipment would be a 4-cubic-yard (PCSA-heaped) bucket.

Investment cost estimate - backhoe dredge (hydraulic operated)(1)

Component	600-cubic yard per hour capability (800 hp) Unit	Unit cost	Number	Cost	250-cubic yard per hour capability (250 hp) Unit	Unit cost	Number	Cost
Hull								
1976 price (P.I.2399.9)								
110x20x6 feet		$137,000				$137,000		
1978 price (P.I.2775.9)		158,500				158,500		
Size adjustment	-				50x20x6 feet			
60x30x6 feet	Lump sum	100,000	1	$100,000	Lump sum			$66,500
Hydraulic backhoe								
Mounted unit (k-1266D)	Each	574,300	1	574,300	Each (k-466E)	147,000	1	147,000
Installation (5 percent)	Lump sum	28,700		28,700	Lump sum	7,400		7,400
Subtotal for backhoe unit				603,000				154,400
Spuds and anchors								
Spud assembly (100 lbs/LF)	LF	125	150	18,750	LF	100	150	15,000
Collars	Each	300	3	900	Each	300	3	900
Rams	Each	1,500	6	9,000	Each	1,500	6	9,000
Positioning winch and anchor	Each	5,000	4	20,000	Each	5,000	4	20,000
Winch motor	Each	2,000	4	8,000	Each	2,000	4	8,000
Lines and miscellaneous (20 percent)	Lump sum		1	11,300				10,600
Subtotal for spuds and anchors				67,900				63,500
Electric and automatic control systems								
Electric generator	Each	6,000	1	6,000	Each	6,000	1	6,000
Wiring and navigation aids	Each	3,000	1	3,000	Each	3,000	1	3,000
Vessel positioning control	System	80,000	1	80,000	System	80,000	1	80,000
Subtotal for electric and automatic systems				89,000				89,000
Cost summary								
Hull				100,000				66,500
Backhoe unit				603,000				154,400
Spuds and anchors				67,900				63,500
Control systems				89,000				89,000
Accessories and outfitting (15 percent)				129,000				56,000
Construction costs				988,900				429,400
[illegible] and transportation (20 days)				20,000				20,000
Construction contingencies (20 percent)				198,000				85,900
Design (15 percent)				148,000				64,400
Total				1,354,900				599,700

(1) [illegible] component dredge assemblies - designed primarily for [illegible]

BUCKET-CHAIN DREDGE FLOATING PLANT

During the dredging operation the total floating plant assigned to a bucket-chain dredge would be split into three operations: dredging, transporting, and unloading. The dredging plant would be the dredge and its immediate support as listed in the following table. The placement operation would be the backhoe dredge and its immediate support listed in the table on page 3-10. The transport fleet would be just tenders and barges. The exact number of tenders and barges would depend on the distance from dredge cut to placement site. It is assumed that the tenders used to transport barges would also be used to transport the dredges. For that reason, the dredges, both bucket-chain and backhoe, are not self-propelled.

Either the bucket-chain or backhoe dredge can be paired with a small hydraulic dredge for unloading the barges at the placement site. This system is discussed elsewhere in the appendix.

Bucket-chain dredge - dredging plant

Number	Unit	Investment cost
1	Bucket-chain dredge	$3,257,000
1	400-hp tender	130,000
1	Work barge	63,000
1	Equipment barge	140,000
1	Fuel barge	15,000
1	Swing anchor barge	10,000
1	Crew launch	8,000
1	Survey launch	280,000
2	Skiff and outboard	6,000
Total investment		3,909,000

Number	Unit	Investment cost
1	Backhoe dredge	$1,355,000
1	400-hp tender	130,000
1	Work barge	63,000
1	Equipment barge	140,000
1	Fuel barge	15,000
1	Crew launch	8,000
2	Skiff and outboard	6,000
2	Bulldozers (130-hp)	90,000
1	Office barge	5,000
Total investment		1,812,000

Bucket-chain dredge - disposal site plant

COMPARISON OF INVESTMENT COSTS

Occasionally, the comparison among investment costs of various pieces of equipment can be the deciding factor in choosing the equipment to be used. The following table shows the comparison among several types of dredging equipment assembled into working plants. This table should be used with caution because of the differing types of operation, production rates, and secondary effects (e.g., turbidity) of each, but it does serve to give some insight into the comparisons that can be made. In all cases, the plant tabulated appears to be the best suited all around for dredging on the Upper Mississippi River.

Comparison of investment costs

Type of equipment	Investment cost
20-inch hydraulic dredge (3,000 feet of line)	$10,855,000
16-inch hydraulic dredge (3,000 feet of line)	7,755,000
12-inch hydraulic dredge (2,000 feet of line)	2,943,000
Bucket-chain dredge (2 tenders, 4 barges)	6,741,000

ATTACHMENT 4

RELATIONSHIP OF INDUSTRY CAPABILITY
PROGRAM ESTIMATING PROCEDURES TO
DREDGING COST ESTIMATES

ATTACHMENT 4

RELATIONSHIP OF INDUSTRY CAPABILITY PROGRAM (ICP) ESTIMATING PROCEDURES TO DREDGING COST ESTIMATES

The cost estimating procedures set forth in Corps of Engineers Engineering Regulation 1110-2-1300 are the result of several years of negotiation and effort between the Corps and the dredging industry. It describes a detailed procedure for estimating production rates, crew sizes, fuel requirements, support plant, depreciation, interest on investment, and down time. The intention is to thoroughly document how Government estimates and industry bids are prepared. Each estimate is calculated for one dredging operation such as in a ship canal or harbor approach lasting a significant time longer than a few days and in shoals that are much slower to develop than on the Upper Mississippi River.

In adapting these procedures to an evaluation of GREAT I's channel maintenance plan, as much as possible of the original procedures was retained. Production rates and operational characteristic curves were used but cut face estimates and reduction factors for shallow faces were adjusted to closer reflect past experience.

The methods of estimating labor costs, depreciation, operational costs, and costs of ownership were not changed from the regulations. As mentioned in other attachments, equipment investment costs and other costs were not available in some cases. In these instances, costs were estimated and are documented in this appendix to the GREAT I report.

The GREAT study process began before the ICP existed. At that time, GREAT's primary interest regarding equipment was how to conduct business within the restraints of the moratorium. As more and more national inte for contracted dredging developed, GREAT's emphasis shifted away from Co owned equipment to contract procedures and costs of dredging individual sites by various equipment types.

ATTACHMENT 5

PLAN EVALUATION LEVEL
DREDGING COST ESTIMATES

TABLE OF CONTENTS

TABLES

ATTACHMENT 5

PLAN EVALUATION LEVEL DREDGING COST ESTIMATES

INTRODUCTION

This attachment describes the third of the three levels of cost estimates prepared by the MENWG (Material and Equipment Needs Work Group). The first level was meant to provide a display of information on each cut and placement site in the material placement category matrix (Matrix B) from which alternative plan costs could be extracted. The second level was developed as a tool to be used by the Channel Maintenance Task Force to select sites for the material placement plans.

The plan evaluation level cost estimates were meant to provide a detailed evaluation of the cost to implement the channel maintenance plan and to develop data on which to base dredging equipment recommendations.

The estimates produced are largely based on ER 1110-2-1300 - Government Estimates and Hired Labor Estimates for Dredging with some modifications for local situations as explained later. Because the present Government fleet available numbers only 3 of the 11 dredging plants included in the plan evaluation level program and the interest shown by both local contractors and members of the GREAT I team in having maintenance dredging done by contract, the plan evaluation level estimates assume the work will be done under contract.

PROGRESSIVE DEVELOPMENT FROM PLAN FORMULATION LEVEL

Of primary importance following the Dredging Equipment Seminar was development of mechanical dredging data equivalent to hydraulic dredging data already in hand and being improved. Three basic types were explored: the barge-mounted crane-clamshell, an endless chain bucket ladder dredge, and a barge-mounted hydraulic backhoe. Investment costs for the bucket ladder and hydraulic backhoe were prepared (see Attachment 3).

The plan formulation level program assumptions are based primarily on ER 1110-2-1300, issued in February 1978. The purpose of this regulation is to provide the estimator with general data, procedures, average values, and a format for guidance in preparing Government estimates and hired labor estimates for hopper dredging and hydraulic pipeline dredging. This regulation also outlines the procedure required to determine the total contract costs, or the total hired labor costs. With this as a base for both procedure and format, a comprehensive data base for preparation of monthly dredging plant costs was developed for all dredging plants. These actual computations are shown later in this attachment and are consistent, as far as possible, with Appendix C of ER 1110-2-1300 (see attachment 6).

PROGRAM DATA

Daily cost rates for the various dredge plants (or portions of dredge plants) are computed on Tables of Daily Cost Rates for Plant Operation. The costs shown in each part are used as various components of the total dredging cost once the production rate and time necessary to do the dredging are determined.

ITEM DESCRI- TIONS AND ASSUMPTIONS

HYDRAULIC DREDGES

Part I

a. Payroll (supervisor and engineer) documents the central office and field office supervisor staff costs for the operation. All nonshift people who supervise or inspect the overall dredging operation are to be accounted for here.

These costs were assigned to the dredging operation on a 5-day work week rate rather than the 6-day work week for the operating crew. Also, when travel time exceeded 2 days total, only 60 percent of this rate was charged during mobilization. The reason for this is that under usual conditions the civil engineer, chief surve surveyor, and inspector would not be employed by the dredge extended mobilization.

b. Payroll (operations, dredging) is the [illegible] job during dredging.

This crew labor rate is charged to the dredging operation for the entire time the dredge is committed to the dredging project except for certain mobilization conditions mentioned below.

c. Payroll (operations, transit) is the staff on the job during certain mobilization and set-up conditions:

(1) At those times when the days needed to actually dredge the cut indicate that the plant could easily be moved on weekends.

(2) When total travel time to reach the dredging site exceeds 4 days.

Travel time and mobilization is computed from Fountain City, Wisconsin. The work group felt that using a full crew during travel from this central location would compensate for privately owned dredges traveling a longer distance with a reduced crew. Also, this reflects present Corps practice during mobilization of the *Dredge* **Thompson**.

<u>Part II</u>

Ownership and operation documents the investment and depreciation of equipment. The life shown is what is used by the Corps in depreciating the present equipment. The monthly costs column is actually a straight-line depreciation to zero value at the end of the equipment lifetime. The total investment in plant is at the bottom of the "value" column. The values shown are meant to be replacement costs at 1978 price levels. Where these costs were not known, estimates were made by comparing known costs of similar equipment or assembling a value from the "Green Guide" published by Equipment Guide-Book Company.

Other ownership costs documents the costs of owning the equipment - interest, supplies, repairs, etc. Interest on investment is computed as simple annual interest on the total investment divided by the months per year of operation. The error introduced by this approach is within the precision of other factors.

Yard cost, supplies, and repair are derived from the "Contractors' Equipment Manual" published by the Associated General Contractors of America. This organization supplies factors for average hourly repair and maintenance expense in percent of new acquisition cost. This factor includes labor (35 percent), parts and supplies (45 percent), shop overhead (8 percent), fleet support (8 percent), and outside repairs (4 percent). Shop overhead and fleet support are part of the final yard cost factor. Parts and supplies are shown as supplies and hardware, and outside repairs are shown as repair and dry docking. The average use hours per month were adjusted to 315 hours per month. The yard costs, supplies, and outside repairs are the total of the dollar amounts from the last three columns of the following table.

Repair and storage cost (315 hours per month)

Equipment	New cost (1978)	Hourly repair cost	Use adjustment factor	Monthly yard cost (16 percent)	Supplies (45 percent)	Outside repairs (4 percent)
20-inch dredge	$9,450,000	0.000095	0.74	$33,480	$94,170	$8,370
16-inch dredge	6,615,000	0.000095	0.74	23,440	65,920	5,860
12-inch dredge	2,175,000	0.000095	0.74	7,710	21,670	1,930
8-inch Mudcat	110,000	0.000150(1)	0.80(1)	670	1,870	170
20-inch booster	3,780,000	0.000095	0.74	13,390	37,670	3,350
16-inch booster	2,646,000	0.000095	0.74	9,380	26,370	2,340
12-inch booster	870,000	0.000095	0.74	3,080	8,670	770
Bucket-chain dredge(2)	3,260,000	0.000095	0.74	11,550	32,500	2,900
Replace buckets(3)					7,500	
Replace belts(4)					1,700	
Bucket-chain dredge	1,171,000	0.000095	0.74	4,150	11,670	1,040
Backhoe (250-hp)	600,000	0.0116(5)	0.74	1,860	5,230	470
Backhoe (800-hp)	1,355,000	0.0096(6)	0.74	680	1,920	170
Clamshell (250-hp)	600,000	0.000133	0.74	2,980	8,370	740
Clamshell (800-hp)	1,350,000	0.000133	0.74	6,700	18,830	1,670
4,000-hp tender	3,500,000	0.000145	1.00	25,580	71,940	6,400
2,000-hp tender	2,000,000	0.000145	1.00	14,620	41,110	3,650
1,000-hp tender	428,000	0.000145	1.00	3,130	8,800	780
1,000 cubic yard	800,000	0.000056	0.95	2,150	6,030	540
175 cubic yard	200,000	0.000056	0.95	540	1,510	135
Work barges	160,000	0.000056	0.95	430	1,210	110
Equipment barges	200,000	0.000056	0.95	540	1,510	135
Fuel barges	250,000	0.000056	0.95	670	1,890	170
Swing anchor barges	10,000	0.000056	0.95	30	80	10
Crew launch	8,000	0.000203	0.95	80	220	20
Survey launch	280,000	0.000203	0.50	1,430	4,030	360
Bulldozer (130-hp)	55,000	0.000398	1.00	1,100	3,100	280
Bulldozer (80-hp)	30,000	0.000420	1.00	640	1,790	160
400-hp tender	330,000	0.000145	1.00	2,410	6,780	600
200-hp tender	180,000	0.000145	1.00	1,320	3,700	330

(1) Estimated.

(2) The basic bucket-chain dredge without the bucket-chain unit and the conveyor unit is estimated to be equal in repair and storage to hydraulic dredges.

(3) Replace half of the buckets each year.

(4) Replace belt each year.

(5) Estimated: [($603,000 x .0190) + ($752,000 x .0056)]/$1,355,000 = 0.0116.

(6) Estimated: [($155,000 x .0211) + ($455,000 x .0056)]/$600,000 = 0.0096.

Added to the monthly yard costs is 50 percent of the annual charges for dockage and storage at the dock which would be charged against the dredge by the Fountain City Boat Yard. The other 50 percent is the only item under the layup item.

Insurance costs are premiums paid for marine liability, property, public liability, and plant insurance.

Season mobilization is assumed to be 6 working days per year. Costs included are depreciation on the entire plant for 6 days and 6 days of wages for the "transit" crew in Part I.

Fuel costs are based on the total major horsepower items in the assembled plant. The horsepower of the basic dredge and any floating boosters is increased by 30 percent and added to that of the tenders and bulldozers. Again, any error in costs introducted by these assumptions is within the precision of the other items.

For supplies and subsistence costs of quartered plant, a $25 per capita per day charge is assumed; otherwise $35 per day is used.

The pipeline costs should include the factors shown on page 26 of ER 1110-2-1300.

The computations in the program all assume an average of 26 days of dredging per month.

MECHANICAL DREDGES

Because mechanical dredging is not a one-unit dredging and transporting operation, the approach used for hydraulic dredges does not apply. Instead, each operation (dredging, transporting, and unloading barges) was computed separately and the most efficient combination of the three was used. The accounting procedures and assumptions explained in the previous few sections were followed for mechanical dredges as well except where noted.

The completed dredging cost rate sheets included here are based on best available (in 1978) replacement cost data at 1978 price levels. Since that time more reliable replacement cost data have become available. However, the MENWG did not have the time or resources to recompute the dredging cost rates. The table on page 5-50 shows the differences between the newer replacement costs and the replacement costs used in the plan evaluation program.

DREDGING COST RATES FOR PLANT OPERATION

20 inch Dredge 1800 H.P. 24 hour operation 1800 feet transit distance
(a) (b)
(All costs and wage rates in 1978 average dollars)

PART I

No.	PAYROLL (Supervisor and Engineer)	Monthly rate
	Project Manager	$
1	Superintendent	2000
1	Captain	1900
1	Chief Engineer	1900
1	Civil Engineer	1700
1	Office Personnel	1000
1	Chief Surveyor	1100
1	Surveyor	900
1	Inspector	1000
8	Subtotal	11,500
	Taxes, insurance and fringes (26 %)	2990
	Total	14,490 (1)

No.	PAYROLL (Operations, Dredging)	Hourly rate
3	Leverman	$ 10.70
3	Watch Engineers, Strikers	10.70
3	Dredge Mates	10.40
2	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	7.60
2	Welders	8.25
	Oilers	
8	Deckhands	7.00
1	Stewards	9.50
3	Mess Attendants	6.40
	General Dump Foreman	
	Dump Foreman	
	Yard and Shoreman	
	Other	
27	Subtotal	231.40
	Work 56 hours/week Pay 64 hours/week	14,810
	Monthly wages (4.34 weeks	64,280
	Taxes, insurance and fringes (21 %)	13,500 (2)
	Total	77,780

No.	PAYROLL (Operations, Transit)	Hourly rate
2	Watch Engineers	$ 10.70
2	Pilot	10.70
3	Dredge Mates	10.40
2	Tender Masters	9.80
	Tender Operators	
	Tender Mates	
6	Deckhands	7.00
1	Stewards	9.50
3	Mess Attendants	6.40
	Yard and Shoremen	
	Subtotal	164.30
	Work 40 Hours Pay 40 hours/week	6,570
	Monthly wages (4.34 weeks	28,520
	Taxes, insurance and fringes (21 %)	5,990
	Total	34,510 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (Thompson	$ 9,450,000	50 years	$ 31,500
Booster Dredge ( )			
1,000 H.P. Tenders			
2 400 H.P. Tenders @	330,000	50	2200
1 200 H.P. Tenders	180,000	50	600
1 Work barges	160,000	40	670
1 Equipment barges	200,000	40	~~830~~ 1040
~~1 Fuel-water barges~~	~~250,000~~	~~40~~	
1 Swing anchor barges	10,000	40	40
1 Crew launch	8,000	40	30
1 Survey launch	280,000	40	1170
2 Skiff and outboard @	3,000	4	250
Hoist (T.)			
Derrick (T.)			
2 Bulldozers 130 H.P. @	55,000	20	920
1 Pickup trucks	5,000	4	210
Office barge (trailer)			
Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	11,319,000		2090
Total depreciation			41,550 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$207,500 month	
Yard cost	45,000	
Insurance	4,300	
Season mobilization	17,550	
Lay up (6 month/year)	880	
Supplies, hardware	126,570	
Repair and dry docking	11,270	
Total other ownership costs		$ 413,070 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 3600 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$ 49,400 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	2,090	
Supplies, subsistance	17,550	
Total other operating costs		$ 69,540 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	1000	$	$ 2.98	$
Shoreline	800		1.50	
Total				4180

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X) 5-8	557	2992	1327	1598	15887	2675	39	8

c1 1

20 V (a) 18 V (b)

DREDGING COST RATES FOR [illegible]

20" Inch Dredge 1800 H.P. 24 hour operation 2800 Dredging operation only
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)

		Monthly rate
1	Project Manager	
1	Superintendent	2000
1	Captain	1900
1	Chief Engineer	1900
1	Civil Engineer	1700
1	Office Personnel	1000
1	Chief Surveyor	1100
1	Surveyor	900
1	Inspector	1000
8	Subtotal	11,500
	Taxes, Insurance and fringes (26 %)	2990
	Total	14,490 (1)

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$ 10.70
3	Watch Engineers, Strikers	10.70
6	Dredge Mates	10.40
2	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	7.60
2	Welders	8.25
	Oilers	
12	Deckhands	7.00
1	Stewards	9.50
3	Mess Attendants	6.40
1	General Duty Foreman	10.70
	Dump Foreman	
8	Yard and Shoreman	7.60
	Other	
43	Subtotal	362.1
	Work 56 hours/week; Pay 64 hours/week	23170
	Monthly wages (4.34 weeks)	100560
	Taxes, insurance and fringes (21 %)	21120 (2)
	Total	121680

PAYROLL (Operations, Transit)

		Hourly rate
2	Watch Engineers	10.70
2	[illegible]	10.70
3	Dredge Mates	10.40
2	Tender [illegible]	9.80
	Tender Operators	
	Tender Mates	
6	Deckhands	7.00
1	Stewards	9.50
3	Mess Attendants	6.40
	Yard and Shoremen	
19	Subtotal	164.3
	Work 40 hours/week; Pay 40 hours/week	6570
	Monthly wages (4.34 weeks)	28510
	Taxes, insurance and fringes (21 %)	5990
	Total	34500 (3)

PART II

[illegible] 6 [illegible]

	Plant	Cost	Life	Monthly
	Dredge Thompson	$ 9,450,000	50	31,500
	[illegible]			
1	[illegible]	428,000	50	1430
2	[illegible]	330,000	50	2200
1	[illegible]	180,000	50	600
1	[illegible]	160,000 / 200,000	40 / 48	670 / 830
1	Equipment barges			
1	Fuel/water barges	250,000	40	1040
1	Belly anchor barges	10,000	40	40
1	Crew launch	8,000	40	30
1	Survey launch	280,000	40	1170
2	Skiff and outboard	3,000	4	250
	Hoist [illegible]			
	Derrick [illegible]			
2	Bulldozers 130 H.P.	55,000	20	920
1	Pickup trucks	5,000	4	210
	Office barge (trailer)			
	Tractor trailer			
	Pipeline (50 % of pipeline costs from Part III)	11,747,000		3730
	Total depreciation			46,710 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	215,360	
Yard cost	48,130	
Insurance	4,300	
Season mobilization	18,190	
Lay up (6 month [illegible])	880	
Supplies, hardware	135,370	
Repair and dry docking	12,050	
Total other ownership costs		434,280 (5)

OTHER OPERATING COSTS

Fuel Cost: 315 hours/month × H.P. × .067 gallon/H.P. hour × $ .65 /gallon	52,130	
Water and lubricants	500	
Pipeline [illegible] costs from Part [illegible]	3430	
Supplies, subsistance	33,150	
Total other operating costs		[illegible] (6)

PART III

PIPELINE COST

		Unit cost	
Floating line	1800	2.98	5364
Shoreline	1000	1.50	1500
Total			6864

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUT

Variable					
[illegible]	557	4680	1327	1797	16703 2223

BH (a) DR (b)

DREDGING COST RATES FOR PLANT OPERATION

20" inch Dredge 1800 H.P. 24 hour operation 4400 Dredging operation only
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)

		Monthly rate
	Project Manager	$
1	Superintendent	2000
1	Captain	1900
1	Chief Engineer	1900
1	Civil Engineer	1700
1	Office Personnel	1000
1	Chief Surveyor	1100
1	Surveyor	~~900~~ 1000
1	Inspector	
	Subtotal	11500
	Taxes, insurance and fringes (26 %)	2990
	Total	14490 (1)

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$10.70
3	Watch Engineers, Strikers	~~10.70~~ 10.40
6	Dredge Mates	
2	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	7.60
2	Welders	8.25
	Oilers.	
14	Deckhands.	7.00
1	Stewards	9.50
3	Mess Attendants	6.40
1	General Dump Foreman	10.70
	Dump Foreman	
8	Yard and Shoreman	7.60
	Other	
45	Subtotal	376.1
	Work 56 hours/week Pay 64 hours/week	24070
	Monthly wages (4.34 weeks	104460
	Taxes, insurance and fringes (21 %)	21940 (2)
	Total	126400

PAYROLL (Operations, Transit)

		Hourly rate
2	Watch Engineers	$ 10.70
2	Pilot	10.70
3	Dredge Mates	10.40
2	Tender Masters	9.80
	Tender Operators	
	Tender Mates	
6	Deckhands	7.00
1	Stewards	9.50
3	Mess Attendants	6.40
	Yard and Shoremen	
	Subtotal	164.3
	Work 40 Hours Pay 40 hours/week	6570
	Monthly wages (4.34 weeks	28510
	Taxes, insurance and fringes (21 %)	5990
	Total	34500 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (Thompson)	$ 9,450,000	50 years	$ 31,500
Booster Dredge (____)			
1 1,000 H.P. Tenders	428,000	50	1430
2 400 H.P. Tenders @	330,000	50	2200
1 200 H.P. Tenders	180,000	50	600
1 Work barges	160,000	40	
1 Equipment barges	~~200,000~~ 250,000	~~40~~ 40	~~670~~ 830
1 Fuel-water barges			1040
1 Belly anchor barges	10,000	40	40
1 Crew launch	8,000	40	30
1 Survey launch	280,000	40	1170
2 Skiff and outboard @	3,000	4	250
Hoist (___ T.)			
Derrick (___ T.)			
2 Bulldozers 130 H.P. @	55,000	20	920
1 Pickup trucks	5,000	4	210
Office barge (trailer)			
Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	11,747,000		5820
Total depreciation			46,710 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11%)	$215,360/month	
Yard cost	48,130	
Insurance	4,300	
Season mobilization	18,740	
Lay up (6 month/year)	880	
Supplies, hardware	135,370	
Repair and dry docking	12,050	
Total other ownership costs		$430,530 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 4600 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$ 63,100/month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	5,820	
Supplies, subsistence	28,600	
Total other operating costs		$ 98,020 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	3400	$	$ 2.98	$10132
Shoreline	1000		1.50	1500
Total				11632

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X) 5-10	557	4862	1327	1797	16559	3770		

20" Inch Dredge 1800 H.P. 24 hour operation 8000 feet transit
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)

		Monthly rate
	Project Manager	$
1	Superintendent	2000
1	Captain	1900
1	Chief Engineer	1900
1	Civil Engineer	1700
1	Office Personnel	1000
1	Chief Surveyor	1100
1	Surveyor	900
1	Inspector	1000
8	Subtotal	11500
	Taxes, insurance and fringes (21 %)	2990
	Total	14490 (1)

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$ 10.70
3	Watch Engineers, Strikers	10.70
6	Dredge Mates	10.40
4	Equipment Operators - Tender	9.80
2	Equipment Operators - On Land	7.60
2	Welders	8.25
	Oilers	
14	Deckhands	7.00
1	Stewards	9.50
3	Mess Attendants	6.40
1	General Dump Foreman	10.70
	Dump Foreman	
8	Yard and Shoreman	7.60
	Other	
47	Subtotal	395.7

Work 56 hours/week
Pay 64 hours/week — 25320

Monthly wages (4.34 weeks) — 109890

Taxes, insurance and fringes (21 %) — 23080 (2)

Total — 132970

PAYROLL (Operations, Transit)

		Hourly rate
2	Watch Engineers	$ 10.70
2	Pilot	10.70
3	Dredge Mates	10.40
2	Tender Masters	9.80
	Tender Operators	
	Tender Mates	
6	Deckhands	7.00
1	Stewards	9.50
3	Mess Attendants	6.40
	Yard and Shoremen	164.3
19	Subtotal	

Work 40 hours/week
Pay 40 hours/week — 6570

Monthly wages (4.34 weeks) — 28510

Taxes, insurance and fringes (21 %) — 5990

Total — 34500 (3)

	Thompson	$ 9,450,000	50	31,500
	Mullen 1200 H.P.	3,780,000	50	12,600
1		428,000	50	1,400
3	@	330,000	50	3,300
2	@	180,000	50	1,200
2	@	~~160,000~~ 200,000	~~40~~ 40	~~1,300~~ 1,700
2	@	250,000	40	2,100
1	Belly anchor barges	10,000	40	40
1		8,000	40	30
1		280,000	40	1,200
2	Skiff and outboard @	3,000	4	250
	Hoist			
	Derrick			
2	Bulldozers 130 H.P. @	55,000	20	920
1	Pickup trucks	5,000	4	210
	Office barge (trailer)			
	Tractor/trailer			
	Pipeline (50% of pipeline costs from Part III)	16,647,000		11,180
	Total depreciation			68,930 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	305,200	
Yard cost	67,890	
Insurance	4,300	
Season mobilization	23,870	
Lay up (6 month year)	880	
Supplies, hardware	188,130	
Repair and dry docking	16,740	
Total other ownership costs		607,010 (5)

OTHER OPERATING COSTS

Fuel cost
315 hours/month x
6760 H.P. x
.067 gallon/hour/H.P. x
$ .65 /gallon — 92,740

Water and lubricants	5,000	
Pipeline (50% of pipeline costs from Part III)	11,180	
Supplies, subsistance	30,550	
Total other operating costs		278,940 (6)

PART III

PIPELINE COSTS

Floating line	7000		2.98	20,860
Shoreline	1000		1.50	1,500
Total				22,360

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV

PART IV

DATA INPUTS

Variable	Subscripts (X)					
	(1)	(2)	(3)			
DREDGE (METHOD, RANGE, X)	557	5114	1327	2651	23347	10728

DREDGING COST RATES FOR PLANT OPERATION

16 (a) inch Dredge 1200 H.P. 24 hour operation 1700 (b) feet transit distance

PART I

PAYROLL (Supervisor and Engineer)

		Monthly rate
	Project Manager	$
1	Superintendent	2000
1	Captain	1900
1	Chief Engineer	1900
1	Civil Engineer	1700
1	Office Personnel	1000
1	Chief Surveyor	1100
1	Surveyor	900
1	Inspector	1000
8	Subtotal	11500
	Taxes, insurance and fringes (21 %)	2990
	Total	14490 (1)

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$10.70
2	Watch Engineers, Strikers	10.70
2	Dredge Mates	10.40
2	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	7.60
1	Welders	8.25
	Oilers.	
8	Deckhands.	7.00
	Stewards	
	Mess Attendants	
1	General Dump Foreman	10.70
	Dump Foreman	
6	Yard and Shoreman	7.60
	Other	
27	Subtotal	229.65
	Work 56 hours/week	
	Pay 64 hours/week	14,700
	Monthly wages (4.34 weeks	63,800
	Taxes, insurance and fringes (21 %)	13,400 (2)
	Total	77,200

PAYROLL (Operations, Transit)

		Hourly rate
2	Watch Engineers	$10.70
2	Pilot	10.70
2	Dredge Mates	10.40
2	Tender Masters	9.80
	Tender Operators	
	Tender Mates	
6	Deckhands	7.00
	Stewards	
	Mess Attendants	
	Yard and Shoremen	
	Subtotal	125.2
	Work 40 Hours Pay	5010
	Pay 40 hours/week	
	Monthly wages (4.34 weeks	21740
	Taxes, insurance and fringes (21 %)	4570
	Total	26310 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly
Dredge (Robers)	$ 6,615000	50 years	22,050
Booster Dredge ( )			
1,000 H.P. Tenders			
1 400 H.P. Tenders	330,000	50	1 100
2 200 H.P. Tenders @	180,000	50	2,300
1 Work barges	160,000	40	670
1 Equipment barges	200,000	40	830
1 Fuel-water barges	250,000	40	1,000
1 Belly anchor barges	10,000	40	40
2 Crew launch @	8,000	40	70
1 Survey launch	280,000	40	1,200
4 Skiff and outboard @	3,000	4	5,000
Hoist ( )			
Derrick (			
2 Bulldozers 130 HP @	55,000	20	920
3 Pickup trucks @	5,000	4	630
1 Office barge (trailer)	5,000	6	140
Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	8,363,000		1,830
Total depreciation			37,780 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$153,300/month	
Yard cost	33,950	
Insurance	3,000	
Season mobilization	14,790	
Lay up (6 month/year)	790	
Supplies, hardware	95,460	
Repair and dry docking	8,505	
Total other ownership costs		$ 309,800 (5)

OTHER OPERATING COSTS

Fuel Cost: 315 hours/month X 2620 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$35,940 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	1,830	
Supplies, subsistance	24,570	
Total other operating costs		62,840 (6)

PART III

PIPELINE COSTS

		Mud	Sand	~~Rock~~
Floating line	1000	$	$ 2.75	2750
Shoreline	700		1.30	910
Total				3660

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(2)	
DREDGE (METHOD, RANGE, X)	557	2969	1012	1453	11915	2417	

5

DREDGING COST RATES FOR PLANT OPERATION

16 inch Dredge 1200 H.P. 24 hour operation 2400 feet transit distance

PART I

PAYROLL (Supervisory and Engineer)

		Monthly rate	
	Project Manager		
1	Superintendent	2000	
1	Captain	1900	
1	Chief Engineer	1900	
1	Civil Engineer	1700	
1	Office Personnel	1000	
1	Chief Surveyor	1100	
1	Surveyor	900	
1	Inspector	1000	
	Subtotal	11500	
	Taxes, insurance and fringes (21 %)	2990	
	Total	14490	(1)

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$ 10.70
2	Watch Engineers, Strikers	10.70
4	Dredge Mates	10.40
2	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	7.60
2	Welders	8.25
	Oilers	
10	Deckhands	7.00
	Stewards	
	Mess Attendants	
1	General Dump Foreman	10.70
	Dump Foreman	
6	Yard and Shoreman	7.60
	Other	
32	Subtotal	272.7
	Work 56 hours/week	
	Pay 64 hours/week	17450
	Monthly wages (4.34 weeks)	75750
	Taxes, insurance and fringes (21 %)	15910
	Total	91660

PAYROLL (Operations, Transit)

		Hourly rate
2	Watch Engineers	10.70
2	Pilot	~~10.70~~ 10.40
2	Dredge Mates	9.80
2	Tender Masters	
	Tender Operators	
	Tender Mates	
6	Deckhands	7.00
	Stewards	
	Mess Attendants	
	Yard and Shoremen	
	Subtotal	125.2
	Work 40 hours/week	5010
	Pay 40 hours/week	
	Monthly wages (4.34 weeks)	21740
	Taxes, insurance and fringes (21 %)	4570
	Total	26310

PART II

OWNERSHIP AND DEPRECIATION 6

	Plant			
	Dredge (Robers)	$6,615,000	50	22,050
	Booster Dredge			
1	2,000 H.P. boosters	428,000	50	1,400
1	800 H.P. boosters	330,000	50	1,100
2	250 H.P. tenders @	180,000	50	2,300
1	Work barges	160,000	40	670
1	Equipment barges	200,000	40	830
1	Fuel-water barges	250,000	40	1,000
1	Belly anchor barges	10,000	40	40
~~1~~ 2	Crew launch @	8,000	40	70
1	Survey launch	280,000	40	1,200
4	Skiff and outboard @	3,000	4	5,000
	Hoist ( )			
	Derrick ( )			
2	Bulldozers 130 H.P. @	55,000	20	920
3	Pickup trucks @	5,000	4	630
1	Office barge (trailer)	5,000	6	140
	Tractor/trailer			
	Pipeline (50% of pipeline costs from Part III)	87,910,000		2,580
	Total depreciation			39,930 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$ 161170	
Yard cost	37000	
Insurance	3000	
Season mobilization	15290	
Lay up (6 month year)	790	
Supplies, hardware	104040	
Repair and dry docking	9270	
Total other ownership costs		$ 330,560 (5)

OTHER OPERATING COSTS

Fuel cost 315 hours/month X 3620 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$ 49,660	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	2,580	
Supplies, subsistance	29,120	
Total other operating costs		81,860 (6)

PART III

PIPELINE COSTS

		Mud	Cost	Total
Floating line	1400		2.75	3850
Shoreline	1000		1.30	1300
Total				5150

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUT

Variable	Sub-items X					
	557	3525	1012	1536	12714	3148

DREDGING COST RATES FOR PLANT OPERATION

16 inch Dredge 1200 H.P. 24 hour operation 3500 feet transit distance
(a)

PART I

[illegible] (Supervisor and [illegible])

		Monthly rate
1	[illegible]	$
1	[illegible]	2000
1	[illegible]	1900
1	[illegible] Engineer	1900
1	[illegible] Engineer	1700
1	[illegible] Personnel	~~1000~~ 1100
1	Chief Surveyor	900
1	Surveyor	1000
1	Inspector	11500
	Subtotal	11500
	Taxes, insurance and fringes ( )	2990
	Total	14490 (1)

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$ 10.70
2	Watch Engineers, Strikers	10.70
4	Dredge Mates	10.40
2	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	~~7.60~~ 8.25
2	Welders	
	Oilers	
12	Deckhands	7.00
	Stewards	
	Mess Attendants	
1	General Dump Foreman	10.70
	Dump Foreman	
6	Yard and Shoreman	7.60
	Other	
34	Subtotal	286.7
	Work 56 hours/week Pay 64 hours/week	~~18350~~
	Monthly wages (4.34 weeks	79639
	Taxes, insurance and fringes (21 %)	16720
	Total	96359 (2)

PAYROLL (Operations, Transit)

		Hourly rate
2	Watch Engineers	$ 10.70
2	Pilot	10.70
2	Dredge Mates	10.40
2	Tender Masters	9.80
	Tender Operators	
	Tender Mates	
6	Deckhands	7.00
	Stewards	
	Mess Attendants	
	Yard and Shoremen	
	Subtotal	125.2
	Work 40 hours/day [illegible] Pay 40 hours/week	5010
	Monthly wages (4.34 weeks	21740
	Taxes, insurance and fringes (21 %)	4570
	Total	26310 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

	Plant	Value (estimate)	Life		Monthly costs
	Dredge (Robers)	$6,615,000	50	years	$22,050
	Booster Dredge ( )				
1	1,000 H.P. Tenders	428,000	50		1,400
1	400 H.P. Tenders	330,000	50		1,100
2	200 H.P. Tenders @	~~180,000~~ 160,000	~~50~~ 40		~~2,300~~ 670
1	Work barges				
1	Equipment barges	200,000	40		830
1	Fuel-water barges	250,000	40		1,000
1	Belly anchor barges	10,000	40		40
2	Crew launch @	8,000	40		70
1	Survey launch	280,000	40		1,200
4	Skiff and outboard @	3,000	4		5,000
	Hoist (T.)				
	Derrick (T.)				
2	Bulldozers 130 H.P. @	55,000	20		920
3	Pickup trucks @	5,000	4		630
1	Office barge (trailer)	5,000	6		140
	Tractor/trailer				
	Pipeline (50% of pipeline costs from Part III)	8,791,000			4,090
	Total depreciation				41,440 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$161,170 month	
Yard cost	37,000	
Insurance	3,000	
Season mobilization	15,630	
Lay up (6 month/year)	790	
Supplies, hardware	104,040	
Repair and dry docking	9,270	
Total other ownership costs		$330,560 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 3620 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$ 49,660 month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	4,090	
Supplies, subsistance	30,940	
Total other operating costs		$ 85,190 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	2500	$	$ 2.75	$ 6.875
Shoreline	1000		1.30	1,300
Total				8,175

Note: Assume working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	557	3706	1012	1594	12714	3277		

7

DREDGING COST RATES FOR PLANT OPERATION

16 inch Dredge 1200 H.P. 24 hour operation 6000 feet transit distance
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
___ Project Manager	$
1 Superintendent	2,000
1 Captain	1,900
1 Chief Engineer	1,900
1 Civil Engineer	1,700
1 Office Personnel	1,000
1 Chief Surveyor	1,100
1 Surveyor	900
1 Inspector	1,000
Subtotal	11,500
Taxes, insurance and fringes (21 %)	2,990
Total	14,490 (1)

PAYROLL (Operations, Dredging)	Hourly rate
3 Leverman	$ 10.70
2 Watch Engineers, Strikers	10.70
4 Dredge Mates	10.40
3 Equipment Operators - Tender	9.80
2 Equipment Operators - On land	7.60
2 Welders	8.25
___ Oilers.	
12 Deckhands.	7.00
___ Stewards	
___ Mess Attendants	
1 General Dump Foreman	10.70
___ Dump Foreman	
6 Yard and Shoreman	7.60
___ Other ________	
35 Subtotal	296.5
Work 56 hours/week Pay 64 hours/week	18980
Monthly wages (4.34 weeks	82,370
Taxes, insurance and fringes (21 %)	17,300 (2)
Total	99,670

PAYROLL (Operations, Transit)	Hourly rate
2 Watch Engineers	$ 10.70
2 Pilot	10.70
2 Dredge Mates	10.40
3 Tender Masters	9.80
___ Tender Operators	
___ Tender Mates	
6 Deckhands	7.00
___ Stewards	
___ Mess Attendants	
___ Yard and Shoremen	
Subtotal	135.0
Work 40 Hours Pay Pay 40 hours/week	5400
Monthly wages (4.34 weeks	23440
Taxes, insurance and fringes (21 %)	4970
Total	28360 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (Robers)	$6,615,000	50 years	22,050
Booster Dredge (______)			
1 1,000 H.P. Tenders	428,000	50	1,400
2 400 H.P. Tenders @	330,000	50	2,200
2 200 H.P. Tenders @	180,000	50	2,300
1 Work barges	160,000	40	670
1 Equipment barges	200,000	40	830
1 Fuel-water barges	250,000	40	1,000
1 Belly anchor barges	10,000	40	40
2 Crew launch @	8,000	40	70
1 Survey launch	280,000	40	1,200
4 Skiff and outboard @	3,000	4	5,000
___ Hoist (___ T.)			
___ Derrick (___ T.)			
2 Bulldozers 130 H.P. @	55,000	20	920
3 Pickup trucks @	5,000	4	630
1 Office barge (trailer)	5,000	6	140
___ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	9,121,000		7,525
Total depreciation			45,970 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$ 167220 /month	
Yard cost	39,410	
Insurance	3,000	
Season mobilization	17,150	
Lay up (6 month/year)	790	
Supplies, hardware	110,820	
Repair and dry docking	9,870	
Total other ownership costs		$ 348,260 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 4020 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$ 55,150 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	15,050	
Supplies, subsistance	31,850	
Total other operating costs		$ 102,550 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	5000	$	$ 2.75	$ 13750
Shoreline	1000		1.30	1300
Total				15050

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	557	3833	1091	1768	13395	3944		

8

DREDGING COST RATES FOR PLANT OPERATION

16 inch Dredge 1200 H.P. 24 hour operation 8500 feet transit distance
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)

		Monthly rate
	Project Manager	$
1	Superintendent	2000
1	Captain	1900
1	Chief Engineer	1900
1	Civil Engineer	1700
1	Office Personnel	1000
1	Chief Surveyor	1100
1	Surveyor	900
1	Inspector	1000
	Subtotal	11500
	Taxes, insurance and fringes (21 %)	2990
	Total	14490 (1)

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$ 10.70
2	Watch Engineers, Strikers	10.70
4	Dredge Mates	10.40
5	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	7.60
2	Welders	8.25
	Oilers.	
12	Deckhands.	7.00
	Stewards	
	Mess Attendants	
1	General Dump Foreman	10.70
	Dump Foreman	
6	Yard and Shoreman	7.60
	Other	
37	Subtotal	316.1
	Work ~~64~~ 56 hours/week Pay hours/week	20230
	Monthly wages (4.34 weeks	87800
	Taxes, insurance and fringes (21 %)	18440 (2)
	Total	106240

PAYROLL (Operations Transit)

		Hourly rate
2	Watch Engineers	$ 10.70
2	Pilot	10.70
2	Dredge Mates	10.40
3	Tender Masters	9.80
	Tender Operators	
	Tender Mates	
6	Deckhands	7.00
	Stewards	
	Mess Attendants	
	Yard and Shoremen	
	Subtotal	135
	Work 40 Hours Pay	5400
	Pay 40 hours/week	
	Monthly wages (4.34 weeks	23440
	Taxes, insurance and fringes (21 %)	4920
	Total	28360 (3)

PART II

OWNERSHIP AND OPERATION (6 month year operation)

Plant		Value (estimate)	Life	Monthly costs
	Dredge (Robers)	$ 6,615,000	50 Years	$22,050
1	Booster Dredge 1000 H.P.	2,646,000	50	8,820
	1,000 H.P. Tenders	428,000	50	1,400
2	400 H.P. Tenders @	330,000	50	2,200
2	200 H.P. Tenders @	180,000	50	2,300
1	Work barges	160,000	40	670
1	Equipment barges	200,000	40	830
1	Fuel-water barges	250,000	40	1,000
1	Belly anchor barges	10,000	40	40
2	Crew launch @	8,000	40	70
1	Survey launch	280,000	40	1,200
4	Skiff and outboard @	3,000	4	5,000
	Hoist (T.)			
	Derrick (T.)			
2	Bulldozers 130 HP @	55,000	20	920
3	Pickup trucks @	5,000	4	630
1	Office barge (trailer)	5,000	6	140
	Tractor/trailer			
	Pipeline (50% of pipeline costs from Part III)	11,767,000		10,960
	Total depreciation			58,230 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$215730 /month	
Yard cost	48,790	
Insurance	3,000	
Season mobilization	19,980	
Lay up (6 month/year)	790	
Supplies, hardware	137,190	
Repair and dry docking	12,205	
Total other ownership costs		$ 437,690 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 5320 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$72,980 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	10,960	
Supplies, subsistance	33,670	
Total other operating costs		$ 118,110 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	7500	$	$ 2.75	$ 20,625
Shoreline	1000		1.30	1,300
Total				21,925

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	557	4086	1091	2240	16834	4543		

9

DREDGING COST RATES FOR PLANT OPERATION

12 inch Dredge 1200 H.P. 24 hour operation 1500 feet transit distance

PART I

PAYROLL (Supervisor and Engineer)

		Monthly rate
	Project Manager	$
.5	Superintendent	2000
	Captain	
1	Chief Engineer	1900
1	Civil Engineer	1700
.5	Office Personnel	1000
.5	Chief Surveyor	~~1100~~ 900
.5	Surveyor	900
1	Inspector	1000
	Subtotal	7100
	Taxes, insurance and fringes (21)	1490
	Total	8590 (1)

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$ 10.70
2	Watch Engineers, Strikers	10.70
2	Dredge Mates	10.40
1	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	7.60
1	Welders	8.25
	Oilers	
4	Deckhands	7.00
	Stewards	
	Mess Attendants	
1	General Dump Foreman	10.70
	Dump Foreman	
4	Yard and Shoreman	7.60
	Other	
20	Subtotal	176.65
	Work 56 hours/week; Pay 64 hours/week	11310
	Monthly wages (4.34 weeks	49090
	Taxes, insurance and fringes (21)	10310 (2)
	Total	59400

PAYROLL (Operations, Transit)

		Hourly rate
2	Watch Engineers	10.70
2	Pilot	10.70
2	Dredge Mates	10.40
1	Tender Masters	9.80
	Tender Operators	
	Tender Mates	
4	Deckhands	7.00
	Stewards	
	Mess Attendants	
	Yard and Shoremen	
	Subtotal	101.4
	Work 40 hours/week; Pay 40 hours/week	4060
	Monthly wages (4.34 weeks	17620
	Taxes, insurance and fringes (21)	3700
	Total	21320 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (Dubuque)	$ 2,175,000	50 years	$ 7,250
Booster Dredge ( )			
1 1,000 H.P. Tenders	428,000	50	1,430
1 400 H.P. Tenders	330,000	50	1,100
200 H.P. Tenders			
2 Work barges @	160,000	40	1,330
Equipment barges			
1 Fuel-water barges	250,000	40	1,140
1 Belly anchor barges	10,000	40	40
1 Crew launch	8,000	40	30
.5 Survey launch	280,000	40	590
2 Skiff and outboard @	3,000	4	250
Hoist (T.)			
Derrick (T.)			
2 Bulldozers 80 HP @	30,000	20	500
2 Pickup trucks @	5,000	4	420
1 Office barge (trailer)	5,000	6	140
Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	3,742,000		1,530
Total depreciation			15,650 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$ 68,600/month	
Yard cost	16,890	
Insurance	2,500	
Season mobilization	8,530	
Lay up (6 month/year)	725	
Supplies, hardware	47,460	
Repair and dry docking	4,230	
Total other ownership costs		148,940 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 3120 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$ 42800 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	1530	
Supplies, subsistance	18200	
Total other operating costs		63,030 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	1000	$	$ 2.50	$ 2500
Shoreline	500		1.10	550
Total				3050

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	330	2285	820	602	5729	2424		

10

DREDGING COST RATES FOR PLANT OPERATION

12 inch Dredge 1200 H.P. 24 hour operation 2500 feet transit distance

PART I

PAYROLL (Supervisor and Engineer)

		Monthly rate
	Project Manager	$
.5	Superintendent	2000
	Captain	
1	Chief Engineer	1900
1	Civil Engineer	1700
.5	Office Personnel	1000
.5	Chief Surveyor	1100
.5	Surveyor	900
1	Inspector	1000
	Subtotal	7100
	Taxes, insurance and fringes (21 %)	1490
	Total	8590 (1)

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$ 10.70
2	Watch Engineers, Strikers	10.70
2	Dredge Mates	10.40
2	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	~~7.60~~
1	Welders	8.25
	Oilers.	
6	Deckhands.	7.00
	Stewards	
	Mess Attendants	
1	General Dump Foreman	10.70
	Dump Foreman	
4	Yard and Shoreman	~~7.60~~
	Other	
23	Subtotal	~~200.45~~
	Work 56 hours/week	
	Pay 64 hours/week	12830
	Monthly wages (4.34 weeks	55680
	Taxes, insurance and fringes (21 %)	11690 (2)
	Total	67370

PAYROLL (Operations, Transit)

		Hourly rate
2	Watch Engineers	$ 10.70
2	Pilot	10.70
2	Dredge Mates	10.40
1	Tender Masters	9.80
	Tender Operators	
	Tender Mates	
4	Deckhands	~~7.00~~
	Stewards	
	Mess Attendants	
	Yard and Shoremen	
	Subtotal	101.4
	Work 40 Hours Pay	
	Pay 40 hours/week	4060
	Monthly wages (4.34 weeks	~~17620~~
	Taxes, insurance and fringes (21 %)	3700
	Total	21320 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (Dubuque)	$2,175,000	50 years	$7,250
Booster Dredge ( )			
1 1,000 H.P. Tenders	428,000	50	1,430
1 400 H.P. Tenders	330,000	50	1,100
200 H.P. Tenders			
2 Work barges @	160,000	40	1,330
Equipment barges			
1 Fuel-water barges	250,000	40	1,040
1 Belly anchor barges	~~10,000~~	40	40
1 Crew launch	8,000	40	30
.5 Survey launch @	280,000	40	580
3 Skiff and outboard @	3,000	4	380
Hoist (T.)			
Derrick (T.)			
2 Bulldozers 80 HP @	30,000	20	500
3 Pickup trucks @	~~5,000~~	~~4~~	~~625~~
1 Office barge (trailer)	~~5,000~~	~~6~~	~~140~~
Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	3,750,000		2430
Total depreciation			16880 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$68750 month
Yard cost	16890
Insurance	2500
Season mobilization	8820
Lay up (6 month/year)	725
Supplies, hardware	44375
Repair and dry docking	4230
Total other ownership costs	$ 146,290 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 3120 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$ 42800 month
Water and lubricants	500
Pipeline (50% of pipeline costs from Part III)	2430
Supplies, subsistance	20930
Total other operating costs	$ 66,660 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	1500	$	$ 2.50	$ 3750
Shoreline	1000		1.10	~~1100~~
Total				4850

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	330	2591	820	649	5627	2564		

11

DREDGING COST RATES FOR PLANT OPERATION

12 inch Dredge 1200 H.P. 24 hour operation 4000 feet transit distance
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)

		Monthly rate
	Project Manager	$
.5	Superintendent	2000
	Captain	
1	Chief Engineer	1900
1	Civil Engineer	1700
.5	Office Personnel	1000
.5	Chief Surveyor	1100
.5	Surveyor	900
1	Inspector	~~1000~~
	Subtotal	~~7100~~
	Taxes, insurance and fringes (____%)	1490
	Total	8590 (1)

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$ 10.70
2	Watch Engineers, Strikers	10.70
2	Dredge Mates	10.40
3	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	7.60
2	Welders	8.25
	Oilers.	
8	Deckhands.	7.00
	Stewards	
	Mess Attendants	
1	General Dump Foreman	~~10.70~~
	Dump Foreman	
4	Yard and Shoreman	7.60
	Other ______	
27	Subtotal	232.5
	Work 56 hours/week	
	Pay 64 hours/week	~~14880~~
	Monthly wages (4.34 weeks	64580
	Taxes, insurance and fringes (21%)	13560 (2)
	Total	78140

PAYROLL (Operations, Transit)

		Hourly rate
2	Watch Engineers	$ 10.70
2	Pilot	~~10.70~~ 10.40
2	Dredge Mates	9.80
2	Tender Masters	
	Tender Operators	
	Tender Mates	
6	Deckhands	7.00
	Stewards	
	Mess Attendants	
	Yard and Shoremen	125.2
	Subtotal	
	Work 40 Hours Pay	~~5008~~
	Pay 40 hours/week	
	Monthly wages (4.34 weeks	21730
	Taxes, insurance and fringes (21%)	4560
	Total	26290 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

	Plant	Value (estimate)	Life	Monthly costs
	Dredge (Dubuque)	$2,175,000	50 years	$ 7,250
	Booster Dredge (________)			
1	1,000 H.P. Tenders	428,000	50	1,430
1	400 H.P. Tenders	330,000	50	~~1,100~~ 600
1	200 H.P. Tenders	~~180,000~~ 160,000	~~50~~ 40	
2	Work barges @			1,330
	Equipment barges			
1	Fuel-water barges	250,000	40	1,040
1	Belly anchor barges	10,000	40	40
1	Crew launch	8,000	40	30
.5	Survey launch @	280,000	40	580
5	Skiff and outboard @	3,000	4	630
	Hoist (____T.)			
	Derrick (____T.)			
2	Bulldozers 80 HP @	30,000	20	500
4	Pickup trucks @	5,000	4	830
1	Office barge (trailer)	5,000	6	140
	Tractor/trailer			
	Pipeline (50% of pipeline costs from Part III)	3,941,000		4300
	Total depreciation			19800 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$72250 /month	
Yard cost	18210	
Insurance	3000	
Season mobilization	10640	
Lay up (6 month/year)	730	
Supplies, hardware	52670	
Repair and dry docking	4700	
Total other ownership costs		$ 162200 (5)

OTHER OPERATING COSTS

Fuel Cost
315 hours/month X
3320 H.P. X
.067 gallon/hour/H.P. X
$ .65 /gallon = $45540 /month

Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	4300	
Supplies, subsistance	24570	
Total other operating costs		$ 74,910 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	3000	$	$ 2.50	$ 7500
Shoreline	1000		1.10	1100
Total				8600

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	330	3005	1011	762	6239	2881		

12

DREDGING COST RATES FOR PLANT OPERATION

12 inch Dredge (a) 1200 H.P. 24 hour operation 6500 feet (b) transit distance

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
___ Project Manager	$
.5 Superintendent	2000
___ Captain	
1 Chief Engineer	1900
1 Civil Engineer	1700
.5 Office Personnel	1000
.5 Chief Surveyor	1100
.5 Surveyor	900
1 Inspector	1000
Subtotal	7100
Taxes, insurance and fringes (___%)	1490
Total	8590 (1)

PAYROLL (Operations, Dredging)	Hourly rate
3 Leverman	$ 10.70
2 Watch Engineers, Strikers	10.70
3 Dredge Mates	10.40
3 Equipment Operators - Tender	9.80
2 Equipment Operators - On land	7.60
2 Welders	8.25
___ Oilers.	
10 Deckhands.	7.00
___ Stewards	
___ Mess Attendants	
1 General Dump Foreman	10.70
___ Dump Foreman	
4 Yard and Shoreman	7.60
___ Other ______	
30 Subtotal	256.9
Work 56 hours/week Pay 64 hours/week	16440
Monthly wages (4.34 weeks	71350
Taxes, insurance and fringes (21 %)	14980 (2)
Total	86330

PAYROLL (Operations, Transit)	Hourly rate
2 Watch Engineers	$ 10.70
2 Pilot	10.70
2 Dredge Mates	10.40
2 Tender Masters	9.80
___ Tender Operators	
___ Tender Mates	
6 Deckhands	7.00
___ Stewards	
___ Mess Attendants	
___ Yard and Shoremen	
Subtotal	125.2
Work 40 Hours Pay 40 hours/week	5008
Monthly wages (4.34 weeks	21730
Taxes, insurance and fringes (21 %)	4560
Total	26290 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (Dubuque)	$2,175,000	50 years	$ 7,250
Booster Dredge 800 HP)	870,000	50	2,900
1 1,000 H.P. Tenders	428,000	50	1,430
1 400 H.P. Tenders	330,000	50	1,100
1 200 H.P. Tenders @	180,000	50	600
2 Work barges	160,000	40	1,330
___ Equipment barges			
1 Fuel-water barges	250,000	40	1,040
1 Belly anchor barges	10,000	40	40
1 Crew launch	8,000	40	30
.5 Survey launch @	280,000	40	580
.5 Skiff and outboard @	3,000	4	630
___ Hoist (___ T.)			
___ Derrick (___ T.)			
2 Bulldozers 80 HP @	30,000	20	500
4 Pickup trucks @	5,000	4	830
1 Office barge (trailer)	5,000	6	140
___ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	4,811,000		7080
Total depreciation			25480 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$ 88,200/month	
Yard cost	21,230	
Insurance	3,000	
Season mobilization	11,950	
Lay up (6 month/year)	730	
Supplies, hardware	59,830	
Repair and dry docking	5,330	
Total other ownership costs		$ 190,330 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 4360 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$59,810 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	7,080	
Supplies, subsistance	27,300	
Total other operating costs		$ 94,690 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	5000	$	$ 2.50	$ 12,500
Shoreline	1500		1.10	1,650
Total				14,150

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
DREDGE (METHOD, RANGE, X)	330	3320	1011	980	7320	3642			13

DREDGING COST RATES FOR PLANT OPERATION

8" Mudcat inch Dredge 200 H.P. 16 hour operation 2500 feet transit distanc
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)

	Monthly rate
___ Project Manager	$
___ Superintendent	
.5 Captain	1900
___ Chief Engineer	
___ Civil Engineer	
.5 Office Personnel	1000
.5 Chief Surveyor	1100
.5 Surveyor	900
1 Inspector	1000
Subtotal	3450
Taxes, insurance and fringes (21 %)	720
Total	4170 (1)

PAYROLL (Operations, Dredging)

	Hourly rate
2 Leverman	$ 10.70
___ Watch Engineers, Strikers	
2 Dredge Mates	10.40
___ Equipment Operators - Tender	
2 Equipment Operators - On land	7.60
___ Welders	
___ Oilers.	
4 Deckhands.	7.00
___ Stewards	
___ Mess Attendants	
___ General Dump Foreman	
___ Dump Foreman	
2 Yard and Shoreman	7.60
___ Other ___	
Subtotal	100.6
Work 56 hours/week Pay 64 hours/week	6440
Monthly wages (4.34 weeks	27950
Taxes, insurance and fringes (21 %)	5870 (2)
Total	33820

PAYROLL (Operations, Transit)

	Hourly rate
___ Watch Engineers	$
___ Pilot	
2 Dredge Mates	10.40
___ Tender Masters	
2 ~~Tender~~ Operators Equip.	7.60
___ Tender Mates	
4 Deckhands	7.00
___ Stewards	
___ Mess Attendants	
___ Yard and Shoremen	
Subtotal	64.0
Work 40 Hours Pay 40 hours/week	2560
Monthly wages (4.34 weeks	11110
Taxes, insurance and fringes (21 %)	2330
Total	13440 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (Mudcat)	$110,000	30 years	$ 610
Booster Dredge (___)			
___ 1,000 H.P. Tenders			
___ 400 H.P. Tenders			
1 200 H.P. Tenders	180,000	50	600
1 Work barges	160,000	40	670
___ Equipment barges			
___ Fuel-water barges			
___ Belly anchor barges			
___ Crew launch			
.25 Survey launch	280,000	40	290
4 Skiff and outboard	3,000	4	500
___ Hoist (___ T.)			
___ Derrick (___ T.)			
1 Bulldozers 80 HP	30,000	20	250
2 Pickup trucks	5,000	4	420
1 Office barge (trailer)	5,000	6	170
2 Tractor/trailer	50,000	20	830
Pipeline (50% of pipeline costs from Part III)	677,000		2200
Total depreciation			6,540 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$ 12410 /month
Yard cost	3420
Insurance	1500
Season mobilization	4830
Lay up (6 month/year)	170
Supplies, hardware	9580
Repair and dry docking	860
Total other ownership costs	$ 32,770 (5)

OTHER OPERATING COSTS

Fuel Cost
315 hours/month X
540 H.P. X
.067 gallon/hour/H.P. X
$ .65 /gallon = $ 7410 /month

Water and lubricants	500
Pipeline (50% of pipeline costs from Part III)	2200
Supplies, subsistance	10920
Total other operating costs	$ 21,030 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	2000	$	$ 2.00	$ 4,000
Shoreline	500		.80	400
Total				4,400

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	160	1301	517	252	1260	809		

14

DREDGING COST RATES FOR PLANT OPERATION

8" ~~Mudcat~~ Mudcat inch Dredge 200 H.P. 16 hour operation 5200 feet transit distance
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
Project Manager	$
Superintendent	
.5 Captain	1900
Chief Engineer	
Civil Engineer	
.5 Office Personnel	1000
.5 Chief Surveyor	~~1100~~
.5 Surveyor	~~900~~
1 Inspector	~~1000~~
Subtotal	~~3450~~
Taxes, insurance and fringes (21 %)	720
Total	4170 (1)

PAYROLL (Operations, Dredging)	Hourly rate
2 Leverman	$ 10.70
Watch Engineers, Strikers	
2 Dredge Mates	10.40
Equipment Operators - Tender	
4 Equipment Operators - On land	7.60
Welders	
Oilers.	
6 Deckhands.	~~7.00~~
Stewards	
Mess Attendants	
General Dump Foreman	
Dump Foreman	
2 Yard and Shoreman	7.60
Other	
16 Subtotal	129.8
Work 56 hours/week	
Pay 64 hours/week	~~8310~~
Monthly wages (4.34 weeks	36070
Taxes, insurance and fringes (21 %)	7570 (2)
Total	43640

PAYROLL (Operations, Transit)	Hourly rate
Watch Engineers	$
Pilot	10.40
2 Dredge Mates	
Tender Masters	7.60
2 ~~Tender~~ Equip Operators	
Tender Mates	7.00
4 Deckhands	
Stewards	
Mess Attendants	
Yard and Shoremen	64.0
Subtotal	
Work 40 Hours Pay	~~2560~~
Pay 40 hours/week	11110
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (21 %)	2330
Total	13440 (3)

*first booster barge mounted -$10,000
remainder trailer mounted - $5,000

PART II

OWNERSHIP AND OPERATION (___ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (Mudcat)	$110,000	30 years	$ 610
2* Booster ~~Dredge~~ pumps (100HP)	15,000	10	250
1,000 H.P. Tenders			
400 H.P. Tenders			
1 200 H.P. Tenders	180,000	50	600
1 Work barges	160,000	40	670
Equipment barges			
Fuel-water barges			
Belly anchor barges			
Crew launch			
.25 Survey launch	280,000	40	290
4 Skiff and outboard	3,000	4	500
Hoist (___ T.)			
Derrick (___ T.)			
1 Bulldozers 80 H.P.	30,000	20	250
4 Pickup trucks	5,000	4	830
1 Office barge (trailer)	5,000	6	140
3 Tractor/trailer	50,000	20	1250
Pipeline (50% of pipeline costs from Part III)	752,000		3100
Total depreciation			8490 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$13790 /month	
Yard cost	5400	
Insurance	1500	
Season mobilization	5060	
Lay up (6 month/year)	170	
Supplies, hardware	9580	
Repair and dry docking	860	
Total other ownership costs		$36360 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 800 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$10970 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	3100	
Supplies, subsistance	14560	
Total other operating costs		$ 29130 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	1700	$	$ ~~2.00~~	$ ~~3400~~ 2800
Shoreline	3500		.80	
Total				6200

Note: Assume ___ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
DREDGE (METHOD, RANGE, X)	160	1678	517	327	1398	1120			15

DREDGING COST RATES FOR PLANT OPERATION

8" Mudcatinch Dredge 200 H.P. 16 hour operation 7000 feet transit distance
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
Project Manager	$
Superintendent	
.5 Captain	1900
Chief Engineer	
Civil Engineer	
.5 Office Personnel	1000
.5 Chief Surveyor	~~1100~~
.5 Surveyor	900
1 Inspector	1000
Subtotal	3450
Taxes, insurance and fringes (21 %)	720
Total	4170 (1)

PAYROLL (Operations, Dredging)	Hourly rate
2 Leverman	$ 10.70
Watch Engineers, Strikers	
2 Dredge Mates	10.40
Equipment Operators - Tender	
6 Equipment Operators - On land	7.60
Welders	
Oilers.	
8 Deckhands.	7.00
Stewards	
Mess Attendants	
General Dump Foreman	
Dump Foreman	
2 Yard and Shoreman	7.60
Other	
20 Subtotal	159.0
Work 56 hours/week; Pay 64 hours/week	10180
Monthly wages (4.34 weeks	44180
Taxes, insurance and fringes (21 %)	9280 (2)
Total	53460

PAYROLL (Operations, Transit)	Hourly rate
Watch Engineers	$
Pilot	
2 Dredge Mates	10.40
Tender Masters	
2 Tender ~~Operators~~ Equip	7.60
Tender Mates	
4 Deckhands	7.00
Stewards	
Mess Attendants	
Yard and Shoremen	
Subtotal	64.0
Work 40 hours; Pay 40 hours/week	2560
Monthly wages (4.34 weeks	11110
Taxes, insurance and fringes (21 %)	2330
Total	13440 (3)

*First booster-barge mounted - $10,000
remainder trailer mounted - $5,000

PART II

OWNERSHIP AND OPERATION (month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (Mudcat)	$110,000	30 years	$ 610
4 Booster ~~Dredge~~ pumps (100HP)*	25,000	10	420
1,000 H.P. Tenders			
400 H.P. Tenders			
1 200 H.P. Tenders	~~180,000~~	~~50~~	~~600~~
1 Work barges	~~160,000~~	~~40~~	~~670~~
Equipment barges			
Fuel-water barges			
Belly anchor barges			
Crew launch			
.25 Survey launch	280,000	40	290
4 Skiff and outboard	3,000	4	500
Hoist (T.)			
Derrick (T.)		20	500
2 Bulldozers 80 HP	~~30,000~~		
6 Pickup trucks	5,000	4	1250
1 Office barge (trailer)	5,000	6	140
3 Tractor/trailer	50,000	20	1250
Pipeline (50% of pipeline costs from Part III)	802,000		4240
Total depreciation			10470 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$14,700/month	
Yard cost	5,380	
Insurance	1,500	
Season mobilization	5,520	
Lay up (6 month/year)	170	
Supplies, hardware	11,370	
Repair and dry docking	1,020	
Total other ownership costs		$ 39,660 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 1140 H.P. X .067 gallon/hour/H.P. X $.65 /gallon =	$14940 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	4240	
Supplies, subsistance	18200	
Total other operating costs		$37,380 (6)

PART III

PIPELINE COSTS

		Mud	Sand	Rock
Floating line	2400	$	$ 2.00	$ 4800
Shoreline	4600		~~.80~~	~~3680~~
Total				8480

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	160	2056	517	403	1575	1438		

Subscripts (X)

16

DREDGING COST RATES FOR PLANT OPERATION

Clamshell Dredge 250 H.P. 24 hour operation Dredging Operation Only
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
Project Manager	$
.5 Superintendent	2000
Captain	
1 Chief Engineer	1900
1 Civil Engineer	1700
.5 Office Personnel	1000
.5 Chief Surveyor	1100
.5 Surveyor	900
1 Inspector	1000
Subtotal	7100
Taxes, insurance and fringes (21 %)	1490
Total	8590 (1)

PAYROLL (Operations, Dredging)	Hourly rate
3 Leverman	$ 10.70
2 Watch Engineers, Strikers	10.70
2 Dredge Mates	10.40
3 Equipment Operators - Tender	9.80
Equipment Operators - On land	
Welders	
2 Oilers.	8.80
4 Deckhands.	7.00
Stewards	
Mess Attendants	
General Dump Foreman	
Dump Foreman	
Yard and Shoreman	
Other	
Subtotal	149.3
Work 56 hours/week Pay 64 hours/week	9560
Monthly wages (4.34 weeks	41490
Taxes, insurance and fringes (21 %)	8710
Total	50200 (2)

PAYROLL (Operations, Transit)	Hourly rate
1 Watch Engineers	$ 10.70
Pilot	
1 Dredge Mates	10.40
2 Tender Masters	9.80
Tender Operators	
Tender Mates	
4 Deckhands	7.00
Stewards	
Mess Attendants	
Yard and Shoremen	
Subtotal	68.7
Work 40 Hours Pay Pay 40 hours/week	2750
Monthly wages (4.34 weeks	11940
Taxes, insurance and fringes (21 %)	2510
Total	14450 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge ( )	$ 600,000	50 years	$ 2,000
Booster Dredge ( )			
1 1,000 H.P. Tenders	428,000	50	1,430
400 H.P. Tenders			
1 200 H.P. Tenders	180,000	50	600
2 Work barges @	160,000	40	1,330
1 Equipment barges	200,000	20	830
1 Fuel-water barges	250,000	40	1,040
Belly anchor barges			
1 Crew launch	8,000	40	30
.5 Survey launch @	280,000	40	580
3 Skiff and outboard @	3,000	4	380
Hoist (T.)			
Derrick (T.)			
Bulldozers			
Pickup trucks			
1 Office barge (trailer)	5,000	6	140
Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	2,140,000		0
Total depreciation			8,360 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$ 39230 /month	
Yard cost	10300	
Insurance	300	
Season mobilization	5260	
Lay up (6 month/year)	600	
Supplies, hardware	28930	
Repair and dry docking	2580	
Total other ownership costs		$ 87,200 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 1525 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$ 20,920 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	14,560	
Total other operating costs		$ 35,980 (6)

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			0

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	330	1931	556	322	3334	1384		

17

DREDGING COST RATES FOR PLANT OPERATION

Clamshell Dredge (a) 800 H.P. 24 hour operation Dredging Operation only (b)

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
Project Manager	$
1 Superintendent	2000
1 Captain	1900
1 Chief Engineer	1900
1 Civil Engineer	~~1700~~ 1000
1 Office Personnel	1000
1 Chief Surveyor	1100
1 Surveyor	900
1 Inspector	1000
Subtotal	11500
Taxes, insurance and fringes (___%)	2420
Total	13920 (1)

PAYROLL (Operations, Dredging)	Hourly rate
3 Leverman	$ 10.70
2 Watch Engineers, Strikers	10.70
2 Dredge Mates	10.40
4 Equipment Operators - Tender	9.80
Equipment Operators - On land	
2 Welders	8.25
2 Oilers.	~~8.80~~ 7.00
4 Deckhands.	7.00
Stewards	
Mess Attendants	
General Dump Foreman	
Dump Foreman	
Yard and Shoreman	
Other ______	
19 Subtotal	175.6
Work 56 hours/week Pay 64 hours/week	11240
Monthly wages (4.34 weeks	48780
Taxes, insurance and fringes (21 %)	10240
Total	59020 (2)

PAYROLL (Operations, Transit)	Hourly rate
1 Watch Engineers	$ 10.70
Pilot	
1 Dredge Mates	10.40
2 Tender Masters	9.80
Tender Operators	
Tender Mates	
4 Deckhands	7.00
Stewards	
Mess Attendants	
Yard and Shoremen	
Subtotal	68.7
Work 40 Hours Pay 40 Hours/week	2750
Monthly wages (4.34 weeks	11940
Taxes, insurance and fringes (21 %)	2510
Total	14450 (3)

PART II

OWNERSHIP AND OPERATION (month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (______)	$ 1,350,000	40 years	$ 5,630
Booster Dredge (______)			
1 1,000 H.P. Tenders	428,000	50	1,430
1 400 H.P. Tenders	330,000	50	1,100
200 H.P. Tenders			
2 Work barges @	160,000	40	1,330
2 Equipment barges @	200,000	40	1,670
1 Fuel-water barges	250,000	40	1,040
Belly anchor barges			
1 Crew launch	8,000	40	30
.5 Survey launch @	280,000	40	580
4 Skiff and outboard @	3,000	4	500
Hoist (___T.)			
Derrick (___T.)			
Bulldozers			
Pickup trucks			
1 Office barge (trailer)	5,000	6	140
Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	3,243,000		0
Total depreciation			13,450 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$ 59,460 month	
Yard cost	15,650	
Insurance	600	
Season mobilization	6,440	
Lay up (6 month/year)	705	
Supplies, hardware	43,980	
Repair and dry docking	3,910	
Total other ownership costs		$ 130,745 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 2440 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$33470 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	17290	
Total other operating costs		$ 51,260 (6)

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			0

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Subscripts (X)							
DREDGE (METHOD, RANGE, X)	535	2270	556	517	5029	1972		

DREDGING COST RATES FOR PLANT OPERATION

____ Bucket-chain Dredge 250 H.P. 24 hour operation ____ Dredging Operation
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
____ Project Manager	$ ____
.5 Superintendent	2,000
____ Captain	
1 Chief Engineer	1,900
1 Civil Engineer	1,700
.5 Office Personnel	1,000
.5 Chief Surveyor	1,100
.5 Surveyor	900
1 Inspector	1,000
Subtotal	7,100
Taxes, insurance and fringes (21 %)	1,490
Total	8,590

PAYROLL (Operations, Dredging)	Hourly rate
3 Leverman	$ 10.70
2 Watch Engineers, Strikers	10.70
2 Dredge Mates	10.40
2 Equipment Operators - Tender	9.80
____ Equipment Operators - On land	
____ Welders	
____ Oilers.	
4 Deckhands.	7.00
____ Stewards	
____ Mess Attendants	
____ General Dump Foreman	
____ Dump Foreman	
____ Yard and Shoreman	
____ Other ____	
13 Subtotal	121.9
Work 56 hours/week Pay 64 hours/week	7,800
Monthly wages (4.34 weeks	33,850
Taxes, insurance and fringes (____ %)	7,110
Total	40,960 (2)

PAYROLL (Operations, Transit)	Hourly rate
2 Watch Engineers	$ 10.70
2 Pilot	10.70
2 Dredge Mates	10.40
____ Tender Masters	
____ Tender Operators	
____ Tender Mates	
4 Deckhands	7.00
____ Stewards	
____ Mess Attendants	
____ Yard and Shoremen	
Subtotal	91.6
Work 40 Hours Pay Pay 40 hours/week	3,660
Monthly wages (4.34 weeks	15,880
Taxes, insurance and fringes (21 %)	3,330
Total	19,210 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (____)	00,000	50 years	$ 4,000
Booster Dredge (____)			
1 1,000 H.P. Tenders	[illegible]28,000	50	1,430
____ 400 H.P. Tenders			
____ 200 H.P. Tenders			
1 Work barges	160,000	40	670
____ Equipment barges			
1 Fuel-water barges	250,000	40	1,040
2 Belly anchor barges @	10,000	40	80
1 Crew launch	8,000	40	30
.5 Survey launch @	280,000	40	580
1 Skiff and outboard	3,000	4	130
____ Hoist (____ T.)			
____ Derrick (____ T.)			
____ Bulldozers			
____ Pickup trucks			
____ Office barge (trailer)			
____ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	2,209,000		0
Total depreciation			7,960

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$ 40,500 /month	
Yard cost	9,240	
Insurance	550	
Season mobilization	6,270	
Lay up (6 month/year)	700	
Supplies, hardware	25,970	
Repair and dry docking	2,320	
Total other ownership costs		$85,550

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 325 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$ 4,460 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistence	11,830	
Total other operating costs		$ 16,790

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$ ____	$ ____	$ ____
Shoreline			
Total			0

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	330	1,575	739	306	3,290	646		

DREDGING COST RATES FOR PLANT OPERATION

____Bucket-chain Dredge 800 H.P. 24 hour operation ___Dredging Operation only
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)

	Monthly rate
___ Project Manager	$
1 Superintendent	2,000
1 Captain	1,900
1 Chief Engineer	1,900
1 Civil Engineer	1,700
1 Office Personnel	1,000
1 Chief Surveyor	1,100
1 Surveyor	900
1 Inspector	1,000
Subtotal	11,500
Taxes, insurance and fringes (11 %)	2,420
Total	13,920

PAYROLL (Operations, Dredging)

	Hourly rate
3 Leverman	$ 10.70
2 Watch Engineers, Strikers	10.70
2 Dredge Mates	10.40
2 Equipment Operators - Tender	9.80
___ Equipment Operators - On land	
1 Welders	8.25
___ Oilers.	
4 Deckhands.	7.00
___ Stewards	
___ Mess Attendants	
___ General Dump Foreman	
___ Dump Foreman	
___ Yard and Shoreman	
___ Other ___	
14 Subtotal	130.15
Work 56 hours/week Pay 64 hours/week	8,330
Monthly wages (4.34 weeks	36,150
Taxes, insurance and fringes (21 %)	7,590 (2)
Total	43,740

PAYROLL (Operations, Transit)

	Hourly rate
2 Watch Engineers	$ 10.70
2 Pilot	10.70
2 Dredge Mates	10.40
___ Tender Masters	
___ Tender Operators	
___ Tender Mates	
4 Deckhands	7.00
___ Stewards	
___ Mess Attendants	
___ Yard and Shoremen	
Subtotal	91.6
Work 40 Hours Pay Pay 40 hours/week	3,660
Monthly wages (4.34 weeks	15,880
Taxes, insurance and fringes (___ %)	3,330
Total	19,210 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (___)	3,300,000	50 years	$ 11,000
Booster Dredge (___)			
1 1,000 H.P. Tenders	428,000	50	1,430
___ 400 H.P. Tenders			
___ 200 H.P. Tenders			
1 Work barges	160,000	40	670
___ Equipment barges			
1 Fuel-water barges	250,000	40	1,040
2 Belly anchor barges @	10,000	40	80
1 Crew launch	8,000	40	30
1 Survey launch	28,000	40	1,170
2 Skiff and outboard @	3,000	4	250
___ Hoist (___T.)			
___ Derrick (___T.)			
___ Bulldozers			
___ Pickup trucks			
___ Office barge (trailer)			
___ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	4,452,000		0
Total depreciation			15,670

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$81,620 /month	
Yard cost	17,350	
Insurance	1,500	
Season mobilization	8,050	
Lay up (6 month/year)	750	
Supplies, hardware	58,010	
Repair and dry docking	4,360	
Total other ownership costs		$171,640

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 2,040 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$27,990 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	12,740	
Total other operating costs		$ 41,230

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			0

Note: Assume ___ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	535	1,682	739	603	6,602	1,586		

DREDGING COST RATES FOR PLANT OPERATION

___Barge mounted Backhoe Dredge 250 H.P. _____hour operation___Dredging Operation
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
___ Project Manager	$
.5 Superintendent	2000
___ Captain	
1 Chief Engineer	1900
1 Civil Engineer	1700
.5 Office Personnel	1000
.5 Chief Surveyor	1100
.5 Surveyor	900
1 Inspector	1000
Subtotal	7100
Taxes, insurance and fringes (21 %)	1490
Total	8590 (1)

PAYROLL (Operations, Dredging)	Hourly rate
3 Leverman	$ 10.70
2 Watch Engineers, Strikers	10.70
2 Dredge Mates	10.40
3 Equipment Operators - Tender	9.80
___ Equipment Operators - On land	
___ Welders	
2 Oilers.	8.80
4 Deckhands.	7.00
___ Stewards	
___ Mess Attendants	
___ General Dump Foreman	
___ Dump Foreman	
___ Yard and Shoreman	
___ Other ________	
16 Subtotal	149.3
Work 56 hours/week Pay 64 hours/week	9560
Monthly wages (4.34 weeks	41490
Taxes, insurance and fringes (21 %)	8720 (2)
Total	50210

PAYROLL (Operations, Transit)	Hourly rate
1 Watch Engineers	$ 10.70
___ Pilot	
1 Dredge Mates	10.40
2 Tender Masters	9.80
___ Tender Operators	
___ Tender Mates	
4 Deckhands	7.00
___ Stewards	
___ Mess Attendants	
___ Yard and Shoremen	
Subtotal	68.7
Work 40 Hours Pay Pay 40 hours/week	2750
Monthly wages (4.34 weeks	11940
Taxes, insurance and fringes (21 %)	2510
Total	14450 (3)

PART II

OWNERSHIP AND OPERATION (___ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (__________)	600,000	40 years	$ 2,500
Booster Dredge (__________)			
1 1,000 H.P. Tenders	428,000	50	1,430
___ 400 H.P. Tenders			
1 200 H.P. Tenders	180,000	50	60
2 Work barges @	160,000	40	1,330
1 Equipment barges	200,000	40	830
1 Fuel-water barges	250,000	40	1,040
___ Belly anchor barges			
1 Crew launch	8,000	40	30
.5 Survey launch@	280,000	40	470
3 Skiff and outboard@	3,000	4	380
___ Hoist (___T.)			
___ Derrick (___T.)			
___ Bulldozers			
___ Pickup trucks			
1 Office barge (trailer)	5,000	6	140
___ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	2,140,000		0
Total depreciation			8,210

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$39,230 /month	
Yard cost	8,000	
Insurance	200	
Season mobilization	5,230	
Lay up (6 month/year)	600	
Supplies, hardware	22,480	
Repair and dry docking	2,010	
Total other ownership costs		$77,750

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 1,525 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$20,920 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistence	14,560	
Total other operating costs		$ 35,980

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			0

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	330	1,931	556	316	2,990	1,384		

DREDGING COST RATES FOR PLANT OPERATION

____ Barge Mounted Backhoe Dredge 800 H.P. ____ hour operation ____ Dredging Operation
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
___ Project Manager	$ ____
1 Superintendent	2,000
1 Captain	1,900
1 Chief Engineer	1,900
1 Civil Engineer	1,700
1 Office Personnel	1,000
1 Chief Surveyor	1,100
1 Surveyor	900
1 Inspector	1,000
Subtotal	11,500
Taxes, insurance and fringes (21 %)	2,420
Total	13,920

PAYROLL (Operations, Dredging)	Hourly rate
3 Leverman	$ 10.70
2 Watch Engineers, Strikers	10.70
2 Dredge Mates	10.40
4 Equipment Operators - Tender	9.80
___ Equipment Operators - On land	
2 Welders	8.25
2 Oilers.	8.80
4 Deckhands.	7.00
___ Stewards	
___ Mess Attendants	
___ General Dump Foreman	
___ Dump Foreman	
___ Yard and Shoreman	
___ Other ____	
19 Subtotal	175.6
Work 56 hours/week Pay 64 hours/week	11,240
Monthly wages (4.34 weeks	48,780
Taxes, insurance and fringes (___ %)	10,240 (2)
Total	59,020

PAYROLL (Operations, Transit)	Hourly rate
1 Watch Engineers	$ 10.70
___ Pilot	
1 Dredge Mates	10.40
2 Tender Masters	9.80
___ Tender Operators	
___ Tender Mates	
4 Deckhands	7.00
___ Stewards	
___ Mess Attendants	
___ Yard and Shoremen	
Subtotal	68.7
Work 40 hours Pay Pay 40 hours/week	2,750
Monthly wages (4.34 weeks	11,940
Taxes, insurance and fringes (___ %)	2,500
Total	14,440 (3)

PART II

OWNERSHIP AND OPERATION (6 month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (____)	1,350,000	40 years	$ 5,630
Booster Dredge (____)			
1 1,000 H.P. Tenders	428,000	50	1,430
1 400 H.P. Tenders	330,000	50	1,100
___ 200 H.P. Tenders			
2 Work barges	160,000	40	1,330
2 Equipment barges	200,000	40	1,670
1 Fuel-water barges	250,000	40	1,040
___ Belly anchor barges			
1 Crew launch	8,000	40	30
5 Survey launch	280,000	40	580
4 Skiff and outboard	3,000	4	500
___ Hoist (___ T.)			
___ Derrick (___ T.)			
___ Bulldozers			
___ Pickup trucks			
1 Office barge (trailer)	5,000	6	140
___ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	3,243,000		0
Total depreciation			13,450

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$59,460 /month	
Yard cost	9,720	
Insurance	600	
Season mobilization	6,440	
Lay up (6 month/year)	700	
Supplies, hardware	27,300	
Repair and dry docking	2,440	
Total other ownership costs		$106,660

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 2,440 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$33,470 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	17,290	
Total other operating costs		$ 51,260

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$ ____	$ ____	$ ____
Shoreline			
Total			

Note: Assume ___ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X)					
	(1)	(2)	(3)	(4)	(5)	(6)
DREDGE (METHOD, RANGE, X	535	2,270	555	517	4,102	1,972

DREDGING COST RATES FOR PLANT OPERATION

Clamshell Dredge 250 H.P. 24 hour operation Unloading Barges

(a) (b)

PART I Assigned to barge

PAYROLL (Supervisor and Engineer)	Monthly rate
Project Manager	$
Superintendent	
Captain	
Chief Engineer	
Civil Engineer	
Office Personnel	
Chief Surveyor	
Surveyor	
Inspector	
Subtotal	
Taxes, insurance and fringes (%)	
Total	

PAYROLL (Operations, Dredging)	Hourly rate
Leverman	$
2 Watch Engineers, Strikers	10.70
Dredge Mates	
2 Equipment Operators - Tender	9.80
4 Equipment Operators - On land	7.60
1 Welders	8.25
2 Oilers.	8.80
4 Deckhands.	7.00
Stewards	
Mess Attendants	
1 General Dump Foreman	10.70
Dump Foreman	
Yard and Shoreman	
Other	
16 Subtotal	135.95
Work 56 hours/week Pay 64 hours/week	8,700
Monthly wages (4.34 weeks	37,760
Taxes, insurance and fringes (21 %)	7,930
Total	45,690 (2)

PAYROLL (Operations, Transit)	Hourly rate
1 Watch Engineers	$ 10.70
1 Pilot	10.70
Dredge Mates	
1 Tender Masters	9.80
Tender Operators	
Tender Mates	
4 Deckhands	7.00
Stewards	
Mess Attendants	
Yard and Shoremen	
Subtotal	59.2
Work 40 Hours Pay Pay 40 hours/week	2,370
Monthly wages (4.34 weeks	10,290
Taxes, insurance and fringes (21 %)	2,160
Total	12,450 (3)

PART II

OWNERSHIP AND OPERATION (month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge ( )	600,000	40 years	$ 2,500
Booster Dredge ( )			
1,000 H.P. Tenders			
1 400 H.P. Tenders	330,000	40	1,380
200 H.P. Tenders			
1 Work barges	160,000	40	670
1 Equipment barges	200,000	40	830
1 Fuel-water barges	250,000	40	1,040
Belly anchor barges			
1 Crew launch	8,000	40	30
Survey launch			
4 Skiff and outboard	3,000	4	5,000
Hoist (T.)			
Derrick (T.)			
2 Bulldozers 80 H.P.	30,000	20	500
2 Pickup trucks	5,000	4	420
1 Office barge (trailer)	5,000	6	140
Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	1,635,000		0
Total depreciation			12,510

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$29,980 /month	
Yard cost	8,390	
Insurance	270	
Season mobilization	5,760	
Lay up (6 month/year)	600	
Supplies, hardware	23,560	
Repair and dry docking	2,100	
Total other ownership costs		$70,660

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 885 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$12,140 /month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	14,560	
Total other operating costs		$26,700

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			0

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	1,757	479	481	2,718	1,027		

COST RATES FOR PLANT OPERATION

Clamshell Dredge 800 H.P. 24 hour operation ______ Unloading Barges

Assigned to dredge

	PAYROLL (Supervisor and Engineer)	Monthly rate
	Project Manager	$
	Superintendent	
	Total	
	Chief Engineer	
	Engineer	
	Personnel	
	Surveyor	
	Survey	
	Taxes, insurance and fringes	
	Total	

	PAYROLL (Operations, Dredging)	Hourly rate
	Leverman	$
2	Watch Engineers, Strikers	10.70
	Dredge Mates	
4	Equipment Operators - Tender	9.80
8	Equipment Operators - on land	7.60
1	Welders	8.25
2		8.80
4	Deckhands	7.00
	Steward	
	Mess Attendants	
1	Launch Dump Foreman	10.70
	Foreman	
2	and Shoreman	7.60
	Other	
24		201.15
56	hours/week	12,870
64	hours/week	
		55,860
	Taxes, insurance and fringes	11,730
		67,590 (2)

	PAYROLL (Operations, Transit)	Hourly rate
1		$ 10.70
1		10.70
	Mates	
1	Masters	9.80
	Operators	
	Mates	
4		7.00
	Attendants	
	and Shoremen	
	Total	59.20
40	day	2,370
40	week	10,290
	wages weeks	
	insurance and fringes	2,160
		12,450 (3)

PART II

OWNERSHIP AND OPERATION

	Plant	Value (estimate)	Life (month/year operation)	Monthly costs
	Dredge ( )	1,350,000	40 years	$ 5,630
	Booster Dredge ( )			
	1,000 H.P. Tenders			
2	400 H.P. Tenders	330,000	40	2,750
	200 H.P. Tenders			
1	Work barges	160,000	40	670
1	Equipment barges	200,000	40	830
1	Fuel-water barges	250,000	40	
	Belly anchor barges			
1	Crew launch	8,000	40	30
	Survey launch			
5	Skiff and outboard	3,000	4	630
	Hoist (T.)			
	Derrick (T.)			
4	Bulldozers 130 H.P.	55,000	20	1,830
4	Pickup trucks	5,000	4	830
1	Office barge (trailer)	5,000	6	140
	Tractor/trailer			
	Pipeline (50% of pipeline costs from Part III)	2,888,000		0
	Total depreciation			13,340

OTHER OWNERSHIP COSTS

Interest on investment (11%)	$53,190 month	
Yard cost	17,640	
Insurance	600	
Season mobilization	5,950	
Lay up (6 month year)	705	
Supplies, hardware	49,620	
Repair and dry docking	4,430	
Total other ownership costs		$132,135

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 2,360 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$32,380 month	
Water and lubricants	500	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	21,840	
Total other operating costs		$54,720

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			

Note: Assume 26 working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	2,600	479	513	5,082	2,105		

DREDGING COST RATES FOR PLANT OPERATION

1 - 175 cubic yard Barge per tow

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
____ Project Manager	$
____ Superintendent	
____ Captain	
____ Chief Engineer	
____ Civil Engineer	
____ Office Personnel	
____ Chief Surveyor	
____ Surveyor	
____ Inspector	
Subtotal	
Taxes, insurance and fringes (____%)	
Total	

PAYROLL (Operations, Dredging)	Hourly rate
2 Leverman	$ 10.70
.5 Watch Engineers, Strikers	10.70
____ Dredge Mates	
____ Equipment Operators - Tender	
____ Equipment Operators - On land	
____ Welders	
____ Oilers	
4 Deckhands	7.00
____ Stewards	
____ Mess Attendants	
____ General Dump Foreman	
____ Dump Foreman	
____ Yard and Shoreman	
____ Other ____	
Subtotal	54.75
Work 56 hours/week Pay 64 hours/week	3,500
Monthly wages (4.34 weeks	15,190
Taxes, insurance and fringes (____%)	3,190
Total	18,380 (2)

PAYROLL (Operations, Transit)	Hourly rate
____ Watch Engineers	$
____ Pilot	
____ Dredge Mates	
____ Tender Masters	
____ Tender Operators	
____ Tender Mates	
____ Deckhands	
____ Stewards	
____ Mess Attendants	
____ Yard and Shoremen	
Subtotal	
Work Hours Pay	
Pay hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (____%)	
Total	(3)

PART II

OWNERSHIP AND OPERATION (____ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Towboat 1,000 H.P.	428,000	50 years	$1,430
Barge 175)	200,000	40	830
____ 1,000 H.P. Tenders			
____ 400 H.P. Tenders			
____ 200 H.P. Tenders			
____ Work barges			
____ Equipment barges			
____ Fuel-water barges			
____ Belly anchor barges			
____ Crew launch			
____ Survey launch			
____ Skiff and outboard			
____ Hoist (____ T.)			
____ Derrick (____ T.)			
____ Bulldozers			
____ Pickup trucks			
____ Office barge (trailer)			
____ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	628,000		
Total depreciation			2,260

OTHER OWNERSHIP COSTS

Interest on investment (11%)	$144,920/month	
Yard cost	3,670	
Insurance	190	
Season mobilization	1,730	
Lay up (6 month/year)	500	
Supplies, hardware	10,310	
Repair and dry docking	915	
Total other ownership costs		$162,235

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 1,000 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$13,720/month	
Water and lubricants	200	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	5,920	
Total other operating costs		$19,840

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	707	0	87	6,240	763		

DREDGING COST RATES FOR PLANT OPERATION

2 - 175 cubic yard Barge per tow

PART I

	Monthly rate
[illegible]	-
[illegible]	-
[illegible]	-
[illegible]	-
[illegible]	-
[illegible]	-
[illegible]	-
[illegible]	-
[illegible]	-
[illegible]	-
[illegible]	-
Fringes	
[illegible]	0

PAYROLL (Operations, Dredging)

	Hourly rate
2 Leverman	\$ 10.70
2 Watch Engineers, strikers	10.7?
Dredge Mates	
Equipment operators - Tender	
Equipment operators - Land	
Welders	
Oilers	
6 Deckhands	7.00
Stewards	
Mess Attendants	
General Dump Foreman	
Dump Foreman	
Yard and Shoreman	
Other	
Subtotal	68.75
Work 56 hours/week; Pay 64 hours/week	14,400
Monthly wages (4.34 weeks	19,100
Taxes, insurance and fringes (21 %)	4,010 (2)
Total	23,110

PAYROLL (Operations, Transit)

	Hourly rate
___ Watch Engineers	
___ Pilot	
___ Dredge Mates	
___ Tender Masters	
Tender Operators	
___ Tender Mates	
___ Deckhands	
___ Stewards	
___ Mess Attendants	
___ Yard and Shoremen	
Subtotal	
Work Hours Pay	
Pay hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (___ %)	
Total	0 (3)

PART II

Plant	Cost estimate	Life	Monthly
1 Towboat 1,000 H.P.	428,000	50	1,430
2 Barge	200,000	40	1,670
Pipeline (total pipeline costs from Part III)	828,000		
Total depreciation			3,100

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	11,510	
Salvage	4,210	
Insurance	190	
Season mobilization	720	
Lay up (6 month year)	500	
Supplies, hardware	11,820	
Repair and [illegible]	1,050	
Total other ownership costs		30,000

OTHER OPERATING COSTS

Fuel cost: 315 hours month X 1,000 H.P. X .067 gallon/hour H.P. X \$ .65 /gallon =	\$13,720 month	
Water and lubricants	200	
Pipeline (cost of pipeline costs from Part III)	0	
Supplies, subsistance	7,725	
Total other operating costs		21,655

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	\$		\$
Shoreline			
Total			

Note: Assume ___ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	(1)	(2)	(3)	(4)	(5)	(6)
DREDGE (METHOD, RANGE, X)	0	889	0	119	1,154	833

DREDGING COST RATES FOR PLANT OPERATION

4 - 175 cu yd Barge per tow

____ inch Dredge ____ H.P. ____ hour operation ____ feet transit distance

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
____ Project Manager	$____
____ Superintendent	
____ Captain	
____ Chief Engineer	
____ Civil Engineer	
____ Office Personnel	
____ Chief Surveyor	
____ Surveyor	
____ Inspector	
Subtotal	
Taxes, insurance and fringes (____%)	
Total	0

PAYROLL (Operations, Dredging)	Hourly rate
2 Leverman	$ 10.70
.5 Watch Engineers, Strikers	10.70
____ Dredge Mates	
____ Equipment Operators - Tender	
____ Equipment Operators - On land	
____ Welders	
____ Oilers.	
6 Deckhands.	7.00
____ Stewards	
____ Mess Attendants	
____ General Dump Foreman	
____ Dump Foreman	
____ Yard and Shoreman	
____ Other ____________	
Subtotal	68.75
Work 56 hours/week Pay 64 hours/week	4400
Monthly wages (4.34 weeks	19,100
Taxes, insurance and fringes (____%)	4,010
Total	23,110 (2)

PAYROLL (Operations, Transit)	Hourly rate
____ Watch Engineers	$____
____ Pilot	
____ Dredge Mates	
____ Tender Masters	
____ Tender Operators	
____ Tender Mates	
____ Deckhands	
____ Stewards	
____ Mess Attendants	
____ Yard and Shoremen	
Subtotal	
Work ____ Hours Pay Pay ____ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (____%)	0
Total	(3)

PART II

OWNERSHIP AND OPERATION (____ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
~~Dredge~~ (Towboat) 1000HP	$428,000	50 years	$ 1430
4 ~~Booster Dredge~~ (Barges	200,000	40	3330
____ 1,000 H.P. Tenders			
____ 400 H.P. Tenders			
____ 200 H.P. Tenders			
____ Work barges			
____ Equipment barges			
____ Fuel-water barges			
____ Belly anchor barges			
____ Crew launch			
____ Survey launch			
____ Skiff and outboard			
____ Hoist (____T.)			
____ Derrick (____T.)			
____ Bulldozers			
____ Pickup trucks			
____ Office barge (trailer)			
____ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	1,228,000		
Total depreciation			4760 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$22,510 /month	
Yard cost	5,290	
Insurance	190	
Season mobilization	1,100	
Lay up (6 month/year)	500	
Supplies, hardware	14,840	
Repair and dry docking	1,320	
Total other ownership costs		$ 45,750 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 1000 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$13,720 /month	
Water and lubricants	200	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	7,735	
Total other operating costs		$ 21,655 (6)

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$____	$____	$____
Shoreline			
Total			

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	889	0	183	1760	833		

27

DREDGING COST RATES FOR PLANT OPERATION

1- 1000 cu yd Barge per Tow

_____ inch Dredge _______ H.P. _________ hour operation _______ feet transit distance

PART I

PAYROLL (Supervisor and Engineer)

	Monthly rate
Project Manager	$
Superintendent	
Captain	
Chief Engineer	
Civil Engineer	
Field Operations	
Chief Surveyor	
Surveyor	
Inspector	
Subtotal	
Taxes, insurance and fringes (___%)	
Total	0 (1)

PAYROLL (Operations, Dredging)

	Hourly rate
2 Leverman	$ 10.70
1 Watch Engineers, Strikers	10.70
Dredge Mates	
Equipment Operators - Tender	
Equipment Operators - on land	
Welders	
Oilers	
4 Deckhands	7.00
Stewards	
Mess Attendants	
General Dump Foreman	
Dump Foreman	
Yard and Shoreman	
Other	
Subtotal	60.1
Work 56 hours/week	
Pay 64 hours/week	3850
Monthly wages (4.34 weeks	16710
Taxes, insurance and fringes (___%)	3510
Total	20220 (2)

PAYROLL (Operations, Transit)

	Hourly rate
Watch Engineers	$
Pilot	
Dredge Mates	
Tender Masters	
Tender Operators	
Tender Mates	
Deckhands	
Stewards	
Mess Attendants	
Yard and Shoremen	
Subtotal	
Work Hours Pay	
Pay hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (___%)	
Total	0 (3)

PART II

OWNERSHIP AND OPERATION 6 month/year operation

Plant	Value (estimate)	Life	Monthly
1 Towboat 2000HP	$2,000,000	50 years	$ 6670
1 Barge 1000	800,000	40	3330
1,000 H.P. Tenders			
400 H.P. Tenders			
200 H.P. Tenders			
Work barges			
Equipment barges			
Fuel-water barges			
Belly anchor barges			
Crew launch			
Survey launch			
Skiff and outboard			
Hoist (___T.)			
Derrick (___T.)			
Bulldozers			
Pickup trucks			
Office barge (trailer)			
Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	2,800,000		
Total depreciation			10,000 (4)

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$51,330/month	
Yard cost	16,770	
Insurance	910	
Season mobilization	2,310	
Lay up (6 month/year)	700	
Supplies, hardware	47,140	
Repair and dry docking	4,190	
Total other ownership costs		$123,350 (5)

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 2000 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$27,440/month	
Water and lubricants	250	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	6,370	
Total other operating costs		$34,060 (6)

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			

Note: Assume _____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	778	0	385	4744	1316		

Subscripts (X)

28

DREDGING COST RATES FOR PLANT OPERATION

2-1,000 cubic yard Barge per tow

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
____ Project Manager	$______
____ Superintendent	
____ Captain	
____ Chief Engineer	
____ Civil Engineer	
____ Office Personnel	
____ Chief Surveyor	
____ Surveyor	
____ Inspector	
Subtotal	
Taxes, insurance and fringes (____%)	
Total	

PAYROLL (Operations, Dredging)	Hourly rate
2 Leverman	$ 10.70
1 Watch Engineers, Strikers	10.70
____ Dredge Mates	
____ Equipment Operators - Tender	
____ Equipment Operators - On land	
____ Welders	
____ Oilers.	
6 Deckhands.	7.00
____ Stewards	
____ Mess Attendants	
____ General Dump Foreman	
____ Dump Foreman	
____ Yard and Shoreman	
____ Other ______	
Subtotal	74.1
Work 56 hours/week Pay 64 hours/week	4,740
Monthly wages (4.34 weeks	20,570
Taxes, insurance and fringes (____%)	4,320 (2)
Total	24,890

PAYROLL (Operations, Transit)	Hourly rate
____ Watch Engineers	$______
____ Pilot	
____ Dredge Mates	
____ Tender Masters	
____ Tender Operators	
____ Tender Mates	
____ Deckhands	
____ Stewards	
____ Mess Attendants	
____ Yard and Shoremen	
Subtotal	
Work Hours Pay Pay hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (____%)	
Total	______ (3)

PART II

OWNERSHIP AND OPERATION (____ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Towboat 2,000 H.P.	2,000,000	50 years	$ 6,670
2 Barge 1,000	800,000	40	6,670
____ 1,000 H.P. Tenders			
____ 400 H.P. Tenders			
____ 200 H.P. Tenders			
____ Work barges			
____ Equipment barges			
____ Fuel-water barges			
____ Belly anchor barges			
____ Crew launch			
____ Survey launch			
____ Skiff and outboard			
____ Hoist (____T.)			
____ Derrick (____T.)			
____ Bulldozers			
____ Pickup trucks			
____ Office barge (trailer)			
____ Tractor/trailer			0
Pipeline (50% of pipeline costs from Part III)	3,600,000		
Total depreciation			13,340

OTHER OWNERSHIP COSTS

Interest on investment (11%)	$ 66,000 month	
Yard cost	18,920	
Insurance	910	
Season mobilization	3,080	
Lay up (6 month/year)	700	
Supplies, hardware	53,170	
Repair and dry docking	4,730	
Total other ownership costs		$147,510

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 2,000 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$27,440 /month	
Water and lubricants	250	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	8,190	
Total other operating costs		$35,880

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$______	$______	$______
Shoreline			
Total			0

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	957	0	513	5,673	1,380		

4-1,000 cubic yard Barge per tow

PART I

PAYROLL (Supervisor and Engineer)

	Monthly rate
___ Project Manager	$
Superintendent	
Captain	
Chief Engineer	
Civil Engineer	
Office Personnel	
Chief Surveyor	
Surveyor	
Inspector	
Subtotal	
Taxes, insurance and fringes (____%)	
Total	0

PAYROLL (Operations, Dredging)

	Hourly rate
2 Leverman	$ 10.70
1 Watch Engineers, Strikers	10.70
___ Dredge Mates	
___ Equipment Operators - Tender	
Equipment Operators - On land	
___ Welders	
___ Oilers.	
6. Deckhands.	7.00
___ Stewards	
___ Mess Attendants	
___ General Dump Foreman	
___ Dump Foreman	
___ Yard and Shoreman	
___ Other ________	
Subtotal	74.1
Work 56 hours/week Pay 64 hours/week	4,740
Monthly wages (4.34 weeks	20,570
Taxes, insurance and fringes (21 %)	4,320
Total	24,890 (2)

PAYROLL (Operations, Transit)

	Hourly rate
___ Watch Engineers	$
___ Pilot	
___ Dredge Mates	
___ Tender Masters	
___ Tender Operators	
___ Tender Mates	
___ Deckhands	
___ Stewards	
___ Mess Attendants	
___ Yard and Shoremen	
Subtotal	
Work __ Hours Pay Pay __ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (____%)	
Total	(3)

PART II

OWNERSHIP AND OPERATION (___ month/year operation)

Plant	Value (estimate)	Life	Monthly cost
towboat 2,000 H.P.	2,000,000	50 years	6,670
4 Barge 1,000	800,000	40	13,330
___ 1,000 H.P. Tenders			
___ 400 H.P. Tenders			
___ 200 H.P. Tenders			
___ Work barges			
___ Equipment barges			
___ Fuel-water barges			
___ Belly anchor barges			
___ Crew launch			
___ Survey launch			
___ Skiff and outboard			
___ Hoist (____T.)			
___ Derrick (____T.)			
___ Bulldozers			
___ Pickup trucks			
___ Office barge (trailer)			
___ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	5,200,000		
Total depreciation			20,000

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$95,330 month	
Yard cost	23,220	
Insurance	910	
Season mobilization	4,620	
Lay up (6 month/year)	700	
Supplies, hardware	65,230	
Repair and dry docking	5,810	
Total other ownership costs		$ 195,820

OTHER OPERATING COSTS

Fuel Cost
315 hours/month X
2,000 H.P. X
.067 gallon/hour/H.P. X
$ .65 /gallon = $27,440 /month

Water and lubricants	250	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	8,190	
Total other operating costs		$ 35,880

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)			
DREDGE (METHOD, RANGE, X)	0	957	0	769	7,532	1,380

DREDGING COST RATES FOR PLANT OPERATION

6-1,000 cubic yard Barges per tow

PART I

PAYROLL (Supervisor and Engineer)

	Monthly rate
____ Project Manager	$____
____ Superintendent	
____ Captain	
____ Chief Engineer	
____ Civil Engineer	
____ Office Personnel	
____ Chief Surveyor	
____ Surveyor	
____ Inspector	
Subtotal	
Taxes, insurance and fringes (____%)	
Total	0

PAYROLL (Operations, Dredging)

	Hourly rate
2 Leverman	$ 10.70
1 Watch Engineers, Strikers	10.70
____ Dredge Mates	
____ Equipment Operators - Tender	
____ Equipment Operators - On land	
____ Welders	
• Oilers.	
6. Deckhands.	7.00
____ Stewards	
____ Mess Attendants	
____ General Dump Foreman	
____ Dump Foreman	
____ Yard and Shoreman	
____ Other ____	
Subtotal	74.1
Work 56 hours/week, Pay 64 hours/week	4,740
Monthly wages (4.34 weeks	20,570
Taxes, insurance and fringes (____%)	4,320
Total	24,890 (2)

PAYROLL (Operations, Transit)

	Hourly rate
____ Watch Engineers	$____
____ Pilot	
____ Dredge Mates	
____ Tender Masters	
____ Tender Operators	
____ Tender Mates	
____ Deckhands	
____ Stewards	
____ Mess Attendants	
____ Yard and Shoremen	
Subtotal	
Work ____ Hours Pay	
Pay ____ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (____%)	
Total	0 (3)

PART II

OWNERSHIP AND OPERATION (___ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
towboat 2,000 H.P.	2,000,000	50 years	$ 6,670
6 Barge 1,000	800,000	40	20,000
____ 1,000 H.P. Tenders			
____ 400 H.P. Tenders			
____ 200 H.P. Tenders			
____ Work barges			
____ Equipment barges			
____ Fuel-water barges			
____ Belly anchor barges			
____ Crew launch			
____ Survey launch			
____ Skiff and outboard			
____ Hoist (____T.)			
____ Derrick (____T.)			
____ Bulldozers			
____ Pickup trucks			
____ Office barge (trailer)			
____ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	6,800,000		
Total depreciation			26,670

OTHER OWNERSHIP COSTS

Interest on investment (11%)	$124,670 month	
Yard cost	25,370	
Insurance	910	
Season mobilization	6,150	
Lay up (6 month/year)	700	
Supplies, hardware	77,290	
Repair and dry docking	6,890	
Total other ownership costs		$ 241,980

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 2,000 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$27,440 /month	
Water and lubricants	250	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistence	8,190	
Total other operating costs		$35,880

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS:

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE METHOD, RANGE, X)	0	957	0	1,026	9,307	1,380		

Subscripts (X)

DREDGING COST RATES FOR PLANT OPERATION

9-1,000 cubic yard Barges per tow

____ inch Drege ____ H.P. ____ hour operation ____ feet transit distance

(a) (b)

PART I

PAYROLL (Supervisor and Engineer)

	Monthly rate
____ Project Manager	$____
____ Superintendent	
____ Captain	
____ Chief Engineer	
____ Civil Engineer	
____ Office Personnel	
____ Chief Surveyor	
____ Surveyor	
____ Inspector	
Subtotal	
Taxes, insurance and fringes (____%)	
Total	0

PAYROLL (Operations, Dredging)

	Hourly rate
2 Leverman	$ 10.70
1 Watch Engineers, Strikers	10.70
____ Dredge Mates	
____ Equipment Operators - Tender	
____ Equipment Operators - On land	
____ Welders	
____ Oilers.	7.00
6 Deckhands.	
____ Stewards	
____ Mess Attendants	
____ General Dump Foreman	
____ Dump Foreman	
____ Yard and Shoreman	
____ Other ________	
Subtotal	74.1
Work 56 hours/week Pay 64 hours/week	4,740
Monthly wages (4.34 weeks	20,570
Taxes, insurance and fringes (____%)	4,320 (2)
Total	24,890

PAYROLL (Operations, Transit)

	Hourly rate
____ Watch Engineers	$____
____ Pilot	
____ Dredge Mates	
____ Tender Masters	
____ Tender Operators	
____ Tender Mates	
____ Deckhands	
____ Stewards	
____ Mess Attendants	
____ Yard and Shoremen	
Subtotal	
Work ____ Hours Pay Pay ____ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (____%)	
Total	0 (3)

PART II

OWNERSHIP AND OPERATION (____ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
towboat 4,000 H.P.	3,500,000	50 years	$11,670
9 Barges 1,000)	800,000	40	30,000
____ 1,000 H.P. Tenders			
____ 400 H.P. Tenders			
____ 200 H.P. Tenders			
____ Work barges			
____ Equipment barges			
____ Fuel-water barges			
____ Belly anchor barges			
____ Crew launch			
____ Survey launch			
____ Skiff and outboard			
____ Hoist (____T.)			
____ Derrick (____T.)			
____ Bulldozers			
____ Pickup trucks			
____ Office barge (trailer)			
____ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	10,700,000		41,670
Total depreciation			

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$196,170/month	
Yard cost	44,930	
Insurance	1,590	
Season mobilization	9,620	
Lay up (____month/year)	750	
Supplies, hardware	126,210	
Repair and dry docking	11,260	
Total other ownership costs		$390,530

OTHER OPERATING COSTS

Fuel Cost

315 hours/month X
4,000 H.P. X
.067 gallon/hour/H.P. X
$ .65 /gallon = $54,870/month

Water and lubricants	250	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	8,190	
Total other operating costs		$63,310

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$____	$____	$____
Shoreline			
Total			0

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	957	0	1,603	15,020	2,435		

DREDGING COST RATES FOR PLANT OPERATION

12-1,000 cubic yard Barges per tow

_____inch Dredge _____H.P._____hour operation _____feet transit distance

(a) (b)

PART I

PAYROLL (Supervisor and Engineer)

	Monthly rate
_____Project Manager	$_____
_____Superintendent	
_____Captain	
_____Chief Engineer	
_____Civil Engineer	
_____Office Personnel	
_____Chief Surveyor	
_____Surveyor	
_____Inspector	
Subtotal	
Taxes, insurance and fringes (_____%)	
Total	0

PAYROLL (Operations, Dredging)

	Hourly rate
2 Leverman	$ 10.70
1 Watch Engineers, Strikers	10.70
_____Dredge Mates	
_____Equipment Operators - Tender	
_____Equipment Operators - On land	
_____Welders	
_____Oilers.	
6 Deckhands.	7.00
_____Stewards	
_____Mess Attendants	
_____General Dump Foreman	
_____Dump Foreman	
_____Yard and Shoreman	
_____Other_____	
Subtotal	74.1
Work 56 hours/week Pay 64 hours/week	4,740
Monthly wages (4.34 weeks	20,570
Taxes, insurance and fringes (_____%)	4,320 (2)
Total	24,890

PAYROLL (Operations, Transit)

	Hourly rate
_____Watch Engineers	$_____
_____Pilot	
_____Dredge Mates	
_____Tender Masters	
_____Tender Operators	
_____Tender Mates	
_____Deckhands	
_____Stewards	
_____Mess Attendants	
_____Yard and Shoremen	
Subtotal	
Work Hours Pay	
Pay __ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (_____%)	
Total	0 (3)

PART II

OWNERSHIP AND OPERATION (___ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Towboat 4,000 H.P.	3,500,000	50 years	$11,670
12 Barges 1,000	800,000	40	40,000
_____1,000 H.P. Tenders			
_____400 H.P. Tenders			
_____200 H.P. Tenders			
_____Work barges			
_____Equipment barges			
_____Fuel-water barges			
_____Belly anchor barges			
_____Crew launch			
_____Survey launch			
_____Skiff and outboard			
_____Hoist (_____T.)			
_____Derrick (_____T.)			
_____Bulldozers			
_____Pickup trucks			
_____Office barge (trailer)			
_____Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	13,100,000		0
Total depreciation			51,670

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$240,170 month	
Yard cost	51,380	
Insurance	1,590	
Season mobilization	11,920	
Lay up (_____month/year)	750	
Supplies, hardware	144,300	
Repair and dry docking	12,880	
Total other ownership costs		$462,990

OTHER OPERATING COSTS

Fuel Cost		
315 hours/month X		
4,000 H.P. X		
.067 gallon/hour/H.P. X		
$ .65 /gallon =	$54,870 /month	
Water and lubricants	250	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	8,190	
Total other operating costs		$63,310

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$_____	$_____	
Shoreline			
Total			0

Note: Assume _____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	957	0	1,987	17,807	2,435		

DREDGING COST RATES FOR PLANT OPERATION

1-1,000 H.P. Towboat

PART I

PAYROLL (Supervisor and Engineer)

	Monthly rate
Project Manager	$
Superintendent	
Captain	
Chief Engineer	
Civil Engineer	
Office Personnel	
Chief Surveyor	
Surveyor	
Inspector	
Subtotal	
Taxes, insurance and fringes (____%)	
Total	0

PAYROLL (Operations, Dredging)

	Hourly rate
2 ~~Leverman~~ Pilots	$ 10.70
Watch Engineers, Strikers	
Dredge Mates	
Equipment Operators - Tender	
Equipment Operators - On land	
Welders	
Oilers.	
Deckhands.	
Stewards	
Mess Attendants	
General Dump Foreman	
Dump Foreman	
Yard and Shoreman	
Other ________	
Subtotal	21.40
Work 56 hours/week Pay 64 hours/week	1,370
Monthly wages (4.34 weeks	5,950
Taxes, insurance and fringes (___%)	1,250
Total	7,200 (2)

PAYROLL (Operations, Transit)

	Hourly rate
Watch Engineers	$
Pilot	
Dredge Mates	
Tender Masters	
Tender Operators	
Tender Mates	
Deckhands	
Stewards	
Mess Attendants	
Yard and Shoremen	
Subtotal	
Work Hours Pay Pay hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (___%)	
Total	0 (3)

PART II

OWNERSHIP AND OPERATION (___ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Towboat 1,000 H.P.	428,000	50 years	$ 1,430
Booster Dredge			
1,000 H.P. Tenders			
400 H.P. Tenders			
200 H.P. Tenders			
Work barges			
Equipment barges			
Fuel-water barges			
Belly anchor barges			
Crew launch			
Survey launch			
Skiff and outboard			
Hoist (____T.)			
Derrick (____T.)			
Bulldozers			
Pickup trucks			
Office barge (trailer)			
Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	428,000		
Total depreciation			1,430

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$7,850 /month	
Yard cost	3,130	
Insurance	190	
Season mobilization	330	
Lay up (6 month/year)	500	
Supplies, hardware	8,800	
Repair and dry docking	780	
Total other ownership costs		$21,580

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 1,000 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$13,720 /month	
Water and lubricants	200	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	1,820	
Total other operating costs		$15,740

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			

Note: Assume _____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	277	0	55	830	605		

DREDGING COST RATES FOR PLANT OPERATION

1-2,000 H.P. Towboat

PART I

PAYROLL (Supervisor and Engineer)

	Monthly rate
____ Project Manager	$____
____ Superintendent	
____ Captain	
____ Chief Engineer	
____ Civil Engineer	
____ Office Personnel	
____ Chief Surveyor	
____ Surveyor	
____ Inspector	
Subtotal	
Taxes, insurance and fringes (____%)	
Total	0

PAYROLL (Operations, Dredging)

	Hourly rate
2 ~~Leverman~~ Pilots	$ 10.70
____ Watch Engineers, Strikers	
____ Dredge Mates	
____ Equipment Operators - Tender	
____ Equipment Operators - On land	
____ Welders	
____ Oilers.	
____ Deckhands.	
____ Stewards	
____ Mess Attendants	
____ General Dump Foreman	
____ Dump Foreman	
____ Yard and Shoreman	
____ Other ____	
Subtotal	21.40
Work ____ hours/week Pay ____ hours/week	1,370
Monthly wages (4.34 weeks	5,950
Taxes, insurance and fringes (____%)	1,250 (2)
Total	7,200

PAYROLL (Operations, Transit)

	Hourly rate
____ Watch Engineers	$____
____ Pilot	
____ Dredge Mates	
____ Tender Masters	
____ Tender Operators	
____ Tender Mates	
____ Deckhands	
____ Stewards	
____ Mess Attendants	
____ Yard and Shoremen	
Subtotal	
Work ____ Hours Pay Pay ____ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (____%)	
Total	0 (3)

PART II

OWNERSHIP AND OPERATION (____ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Towboat 2,000 H.P.	2,000,000	50 years	$ 6,670
Booster Dredge (________)			
____ 1,000 H.P. Tenders			
____ 400 H.P. Tenders			
____ 200 H.P. Tenders			
____ Work barges			
____ Equipment barges			
____ Fuel-water barges			
____ Belly anchor barges			
____ Crew launch			
____ Survey launch			
____ Skiff and outboard			
____ Hoist (____T.)			
____ Derrick (____T.)			
____ Bulldozers			
____ Pickup trucks			
____ Office barge (trailer)			
____ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	2,000,000		
Total depreciation			6,670

OTHER OWNERSHIP COSTS

Interest on investment (____%)	$36,670 /month	
Yard cost	14,620	
Insurance	910	
Season mobilization	1,540	
Lay up (____ month/year)	700	
Supplies, hardware	41,110	
Repair and dry docking	3,650	
Total other ownership costs		$ 99,200

OTHER OPERATING COSTS

Fuel Cost
315 hours/month X
2,000 H.P. X
.067 gallon/hour/H.P. X
$ .65 /gallon = $27,440 /month

Water and lubricants	250	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistence	1,820	
Total other operating costs		$ 29,510

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$____	$____	$____
Shoreline			
Total			

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	277	0	257	3,815	1,135		

DREDGING COST RATES FOR PLANT OPERATION

1-4,000 H.P. Towboat

PART I

PAYROLL (Supervisor and Engineer)

	Monthly rate
____ Project Manager	$
____ Superintendent	
____ Captain	
____ Chief Engineer	
____ Civil Engineer	
____ Office Personnel	
____ Chief Surveyor	
____ Surveyor	
____ Inspector	
Subtotal	
Taxes, insurance and fringes (____%)	
Total	0

PAYROLL (Operations, Dredging)

	Hourly rate
2 ~~Leverman~~ Pilots	$ 10.70
____ Watch Engineers, Strikers	
____ Dredge Mates	
____ Equipment Operators - Tender	
____ Equipment Operators - On land	
____ Welders	
____ Oilers.	
____ Deckhands.	
____ Stewards	
____ Mess Attendants	
____ General Dump Foreman	
____ Dump Foreman	
____ Yard and Shoreman	
____ Other ________	
Subtotal	21.40
Work 56 hours/week Pay 64 hours/week	1,370
Monthly wages (4.34 weeks	5,950
Taxes, insurance and fringes (21 %)	1,250
Total	7,200 (2)

PAYROLL (Operations, Transit)

	Hourly rate
____ Watch Engineers	$
____ Pilot	
____ Dredge Mates	
____ Tender Masters	
____ Tender Operators	
____ Tender Mates	
____ Deckhands	
____ Stewards	
____ Mess Attendants	
____ Yard and Shoremen	
Subtotal	
Work Hours Pay	
Pay __ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (____%)	
Total	0 (3)

PART II

OWNERSHIP AND OPERATION (___ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Towboat 4,000 H.P.	3,500,000	50 years	$ 11,670
Booster Dredge (________)			
____ 1,000 H.P. Tenders			
____ 400 H.P. Tenders			
____ 200 H.P. Tenders			
____ Work barges			
____ Equipment barges			
____ Fuel-water barges			
____ Belly anchor barges			
____ Crew launch			
____ Survey launch			
____ Skiff and outboard			
____ Hoist (____T.)			
____ Derrick (____T.)			
____ Bulldozers			
____ Pickup trucks			
____ Office barge (trailer)			
____ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)	3,500,000		
Total depreciation			11,670

OTHER OWNERSHIP COSTS

Interest on investment (11 %)	$64,170/month	
Yard cost	25,580	
Insurance	1,590	
Season mobilization	2,690	
Lay up (6 month/year)	750	
Supplies, hardware	71,940	
Repair and dry docking	6,400	
Total other ownership costs		$173,120

OTHER OPERATING COSTS

Fuel Cost 315 hours/month X 4,000 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$54,870/month	
Water and lubricants	250	
Pipeline (50% of pipeline costs from Part III)	0	
Supplies, subsistance	1,820	
Total other operating costs		$56,940

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	277	0	449	6,658	2,190		

DREDGING COST RATES FOR PLANT OPERATION

Pneuma (a) Dredge ______ H.P. ______ hour operation 2,000 (b) feet transit distance

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
____ Project Manager	$________
____ Superintendent	
.5 Captain	1,900
____ Chief Engineer	
____ Civil Engineer	
.5 Office Personnel	1,000
.5 Chief Surveyor	1,100
.5 Surveyor	900
1 Inspector	1,000
Subtotal	3,450
Taxes, insurance and fringes (21 %)	720
Total	4,170

PAYROLL (Operations, Dredging)	Hourly rate
3 Leverman	$ 10.70
2 Watch Engineers, Strikers	10.70
2 Dredge Mates	10.40
1 Equipment Operators - Tender	9.80
2 Equipment Operators - On land	7.60
____ Welders	
1 Oilers.	8.80
____ Deckhands.	
____ Stewards	
____ Mess Attendants	
____ General Dump Foreman	
____ Dump Foreman	
4 Yard and Shoreman	7.60
____ Other ________	
Subtotal	138.5
Work 56 hours/week Pay 64 hours/week	8,860
Monthly wages (4.34 weeks	38,450
Taxes, insurance and fringes (21 %)	8,070 (2)
Total	46,520

PAYROLL (Operations, Transit)	Hourly rate
2 Watch Engineers	$ 10.70
2 Pilot	10.70
2 Dredge Mates	10.40
1 Tender Masters	9.80
____ Tender Operators	
____ Tender Mates	7.00
4 Deckhands	
____ Stewards	
____ Mess Attendants	
____ Yard and Shoremen	101.4
Subtotal	
Work 40 Hours Pay Pay 40 hours/week	4,060
Monthly wages (4.34 weeks	17,620
Taxes, insurance and fringes (21 %)	3,700
Total	21,320 (3)

PART II

OWNERSHIP AND OPERATION (__ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (Pneuma)		___ years	$______
Booster Dredge (________)			
1 1,000 H.P. Tenders	428,000	50	
1 400 H.P. Tenders	330,000	50	
– 200 H.P. Tenders			
1 Work barges	160,000	40	
– Equipment barges			
1 Fuel-water barges	250,000	40	
1 Belly anchor barges	10,000	40	
– Crew launch			
.5 Survey launch	280,000	40	
2 Skiff and outboard	3,000	4	
____ Hoist (____ T.)			
____ Derrick (____ T.)			
2 Bulldozers 80 H.P.	30,000	20	
2 Pickup trucks	5,000	4	
1 Office barge (trailer)	5,000		
____ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)			
Total depreciation			

OTHER OWNERSHIP COSTS

Interest on investment (____ %)	$________ /month	
Yard cost		
Insurance		
Season mobilization		
Lay up (____ month/year)		
Supplies, hardware		
Repair and dry docking		
Total other ownership costs		$________

OTHER OPERATING COSTS

Fuel Cost		
____ hours/month X		
____ H.P. X		
____ gallon/hour/H.P. X		
$________ /gallon =	$________ /month	
Water and lubricants		
Pipeline (50% of pipeline costs from Part III)		
Supplies, subsistance		
Total other operating costs		$________

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$______	$______	$______
Shoreline			
Total			

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)								

DREDGING COST RATES FOR PLANT OPERATION

Pneuma (a) Dredge ______ H.P. ______ hour operation 5,000 (b) feet transit distance

PART I

PAYROLL (Supervisor and Engineer)

		Monthly rate
____	Project Manager	$______
____	Superintendent	
.5	Captain	1,900
____	Chief Engineer	
____	Civil Engineer	
.5	Office Personnel	1,000
.5	Chief Surveyor	1,100
.5	Surveyor	900
1	Inspector	1,000
	Subtotal	3,450
	Taxes, insurance and fringes (____%)	720
	Total	4,170

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$ 10.70
2	Watch Engineers, Strikers	10.70
2	Dredge Mates	10.40
1	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	7.60
____	Welders	
1	Oilers.	8.80
____	Deckhands.	
____	Stewards	
____	Mess Attendants	
____	General Dump Foreman	
____	Dump Foreman	
4	Yard and Shoreman	7.60
____	Other ________	
	Subtotal	

Work 56 hours/week
Pay 64 hours/week — 8,860
Monthly wages (4.34 weeks — 38,450
Taxes, insurance and fringes (____%) — 8,070 (2)
Total — 46,520

PAYROLL (Operations, Transit)

		Hourly rate
2	Watch Engineers	$ 10.70
2	Pilot	10.70
2	Dredge Mates	10.40
1	Tender Masters	9.80
____	Tender Operators	
____	Tender Mates	
4	Deckhands	7.00
____	Stewards	
____	Mess Attendants	101.4
____	Yard and Shoremen	
	Subtotal	

Work 40 Hours Pay
Pay 40 hours/week — 4,060
Monthly wages (4.34 weeks — 17,620
Taxes, insurance and fringes (21 %) — 3,700
Total — 21,320 (3)

PART II

OWNERSHIP AND OPERATION (___ month/year operation)

	Plant	Value (estimate)	Life	Monthly costs
1	Dredge (__________)		____ years	$______
1	Booster Dredge (________)			
1	1,000 H.P. Tenders	428,000	50	
1	400 H.P. Tenders	330,000	50	
____	200 H.P. Tenders			
2	Work barges	160,000	40	
____	Equipment barges			
1	Fuel-water barges	250,000	40	
1	Belly anchor barges	10,000	40	
____	Crew launch			
.5	Survey launch	280,000	40	
2	Skiff and outboard	3,000	4	
____	Hoist (____T.)			
____	Derrick (____T.)			
2	Bulldozers 80 H.P.	30,000	20	
2	Pickup trucks	5,000	4	
1	Office barge (trailer)	5,000		
____	Tractor/trailer			
	Pipeline (50% of pipeline costs from Part III)			
	Total depreciation			

OTHER OWNERSHIP COSTS

Interest on investment (___ %)	$________/month
Yard cost	
Insurance	
Season mobilization	
Lay up (____month/year)	
Supplies, hardware	
Repair and dry docking	
Total other ownership costs	$________

OTHER OPERATING COSTS

Fuel Cost
____hours/month X
____H.P. X
____gallon/hour/H.P. X
$________/gallon = $________/month

Water and lubricants	
Pipeline (50% of pipeline costs from Part III)	
Supplies, subsistence	
Total other operating costs	$________

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$______	$______	$______
Shoreline			
Total			

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE X)								

DREDGING COST RATES FOR PLANT OPERATION

Pneuma (a) Dredge ______ H.P. ______ hour operation 8,000 (b) feet transit distance

PART I

PAYROLL (Supervisor and Engineer)

		Monthly rate
____	Project Manager	$________
	Superintendent	
.5	Captain	1900
____	Chief Engineer	________
____	Civil Engineer	________
.5	Office Personnel	1000
.5	Chief Surveyor	1100
.5	Surveyor	900
1	Inspector	1000
	Subtotal	3450
	Taxes, insurance and fringes (_____%)	720
	Total	4170 (1)

PAYROLL (Operations, Dredging)

		Hourly rate
3	Leverman	$ 10.70
2	Watch Engineers, Strikers	10.70
2	Dredge Mates	10.40
1	Equipment Operators - Tender	9.80
2	Equipment Operators - On land	7.60
____	Welders	________
1	Oilers.	8.80
____	Deckhands.	________
____	Stewards	________
____	Mess Attendants	________
____	General Dump Foreman	________
____	Dump Foreman	________
4	Yard and Shoreman	7.60
____	Other ____________	________
	Subtotal	138.5
	Work 56 hours/week Pay 64 hours/week	8860
	Monthly wages (4.34 weeks	38450
	Taxes, insurance and fringes (_____%)	8070 (2)
	Total	46520

PAYROLL (Operations, Transit)

		Hourly rate
2	Watch Engineers	$ 10.70
2	Pilot	10.70
2	Dredge Mates	9.80
1	Tender Masters	________
____	Tender Operators	________
____	Tender Mates	7.00
4	Deckhands	________
____	Stewards	________
____	Mess Attendants	________
____	Yard and Shoremen	________
	Subtotal	101.4
	Work 40 Hours Pay Pay 40 hours/week	4060
	Monthly wages (4.34 weeks	~~17620~~
	Taxes, insurance and fringes (_____%)	3700
	Total	21320 (3)

PART II

OWNERSHIP AND OPERATION (____ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
1 Dredge (______ ________)	________	____ years	$________
2 Booster Dredge (________)	________		________
1 1,000 H.P. Tenders	428,000	50	________
1 400 H.P. Tenders	330,000	50	________
____ 200 H.P. Tenders	________	____	________
3 Work barges	160,000	40	________
____ Equipment barges	________	____	________
1 Fuel-water barges	250,000	40	________
1 Belly anchor barges	10,000	40	
____ Crew launch	________	____	________
.5 Survey launch	280,000	40	________
2 Skiff and outboard	3,000	4	________
____ Hoist (____T.)	________	____	________
____ Derrick (____T.)	________	____	________
2 Bulldozers 80 H.P.	30,000	20	________
2 Pickup trucks	5,000	4	________
1 Office barge (trailer)	5,000	____	________
____ Tractor/trailer	________	____	________
Pipeline (50% of pipeline costs from Part III)			
Total depreciation			________

OTHER OWNERSHIP COSTS

Interest on investment (_____%)	$________/month	
Yard cost	________	
Insurance	________	
Season mobilization	________	
Lay up (_____month/year)	________	
Supplies, hardware	________	
Repair and dry docking	________	
Total other ownership costs		$________

OTHER OPERATING COSTS

Fuel Cost		
____hours/month X		
____H.P. X		
____gallon/hour/H.P. X		
$________/gallon =	$________/month	
Water and lubricants	________	
Pipeline (50% of pipeline costs from Part III)	________	
Supplies, subsistance	________	
Total other operating costs		$________

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$________	$________	$________
Shoreline		________	________
Total			

Note: Assume _____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, V)								

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3 MATERIAL AND EQUIPMENT NEEDS COMMERCIAL
TRANSPORTATION(U) GREAT RIVER ENVIRONMENTAL ACTION TEAM
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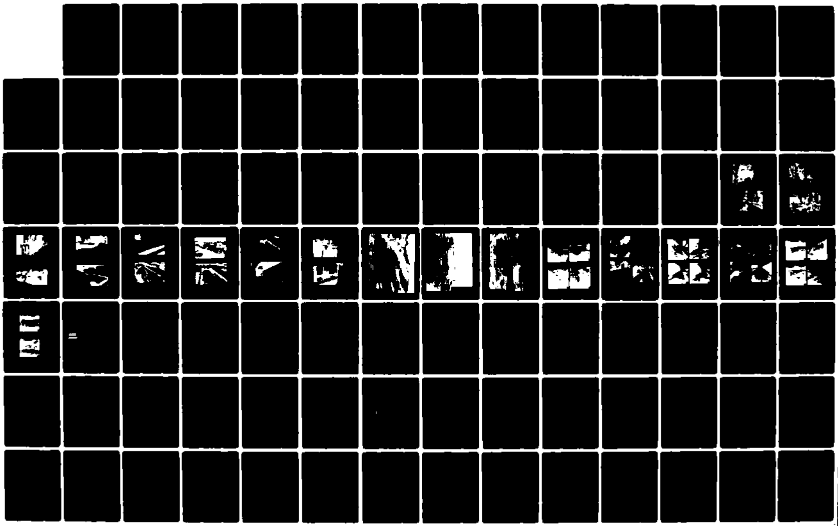
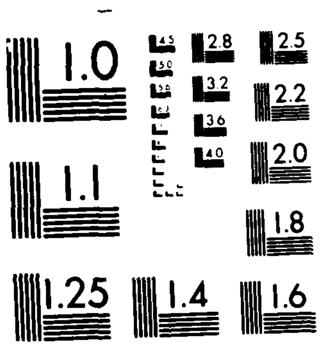




MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

DREDGING COST RATES FOR PLANT OPERATION

Large Dozer (D9)

_____ inch Dredge _____ H.P. _____ hour operation _____ transit distance
(a) (b)

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
_____ Project Manager	$_____
_____ Superintendent	
_____ Captain	
_____ Chief Engineer	
_____ Civil Engineer	
_____ Office Personnel	
_____ Chief Surveyor	
_____ Surveyor	
_____ Inspector	
Subtotal	
Taxes, insurance and fringes (_____%)	
Total	0

PAYROLL (Operations, Dredging)	Hourly rate
_____ Leverman	$_____
_____ Watch Engineers, Strikers	
_____ Dredge Mates	
_____ Equipment Operators - Tender	
1 Equipment Operators - On land	7.60
_____ Welders	
_____ Oilers.	
_____ Deckhands.	
_____ Stewards	
_____ Mess Attendants	
_____ General Dump Foreman	
_____ Dump Foreman	
_____ Yard and Shoreman	
_____ Other _____	
Subtotal	
Work 56 hours/week Pay 64 hours/week	486.40
Monthly wages (4.34 weeks	2,110.98
Taxes, insurance and fringes (_____%)	443.30
Total	2,554.28 (2)

PAYROLL (Operations, Transit)	Hourly rate
_____ Watch Engineers	$_____
_____ Pilot	
_____ Dredge Mates	
_____ Tender Masters	
_____ Tender Operators	
_____ Tender Mates	
_____ Deckhands	
_____ Stewards	
_____ Mess Attendants	
_____ Yard and Shoremen	
Subtotal	
Work _____ Hours Pay Pay _____ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (_____%)	
Total	_____ (3)

PART II

OWNERSHIP AND OPERATION (_____ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (_____)		_____ years	$_____
Booster Dredge (_____)			
_____ 1,000 H.P. Tenders			
_____ 400 H.P. Tenders			
_____ 200 H.P. Tenders			
_____ Work barges			
_____ Equipment barges			
_____ Fuel-water barges			
_____ Belly anchor barges			
_____ Crew launch			
_____ Survey launch			
_____ Skiff and outboard			
_____ Hoist (_____ T.)			
_____ Derrick (_____ T.)			
1 Bulldozers 130 H.P.	55,000	20	460
_____ Pickup trucks			
_____ Office barge (trailer)			
_____ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)			
Total depreciation			460

OTHER OWNERSHIP COSTS

Interest on investment (11%)	$ 1,008 /month	
Yard cost	1,100	
Insurance	100	
Season mobilization	116	
Lay up (_____ month/year)		
Supplies, hardware	3,100	
Repair and dry docking	280	
Total other ownership costs		$ 5,704

OTHER OPERATING COSTS

Fuel Cost 216 hours/month X 130 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$ 1,223 /month	
Water and lubricants	50	
Pipeline (50% of pipeline costs from Part III)		
Supplies, subsistance	910	
Total other operating costs		$ 2,183

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$_____	$_____	$_____
Shoreline			
Total			

Note: Assume _____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	98	0	18	219	84		

DREDGING COST RATES FOR PLANT OPERATION

Medium Dozer (D7)

_____ inch Dredge __80__ H.P. hour operation _____ feet transit distance

(a) (b)

PART I

PAYROLL (Supervisor and Engineer)	Monthly rate
___ Project Manager	$
Superintendent	
___ Captain	
___ Chief Engineer	
___ Civil Engineer	
___ Office Personnel	
___ Chief Surveyor	
___ Surveyor	
___ Inspector	
Subtotal	
Taxes, insurance and fringes (___%)	
Total	

PAYROLL (Operations, Dredging)	Hourly rate
___ Leverman	$
___ Watch Engineers, Strikers	
___ Dredge Mates	
___ Equipment Operators - Tender	
1 Equipment Operators - On land	7.60
___ Welders	
___ Oilers.	
___ Deckhands.	
___ Stewards	
___ Mess Attendants	
___ General Dump Foreman	
___ Dump Foreman	
___ Yard and Shoreman	
___ Other ________	
Subtotal	
Work ___ hours/week	
Pay ___ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (___%)	(2)
Total	2,554

PAYROLL (Operations, Transit)	Hourly rate
___ Watch Engineers	$
___ Pilot	
___ Dredge Mates	
___ Tender Masters	
___ Tender Operators	
___ Tender Mates	
___ Deckhands	
___ Stewards	
___ Mess Attendants	
___ Yard and Shoremen	
Subtotal	
Work Hours Pay	
Pay ___ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (___%)	
Total	(3)

PART II

OWNERSHIP AND OPERATION (___ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (________)		___ years	$
Booster Dredge (________)			
___ 1,000 H.P. Tenders			
___ 400 H.P. Tenders			
___ 200 H.P. Tenders			
___ Work barges			
___ Equipment barges			
___ Fuel-water barges			
___ Belly anchor barges			
___ Crew launch			
___ Survey launch			
___ Skiff and outboard			
___ Hoist (___T.)			
___ Derrick (___T.)			
1 Bulldozers 80 H.P.	30,000	20	250
___ Pickup trucks			
___ Office barge (trailer)			
___ Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)			
Total depreciation			250

OTHER OWNERSHIP COSTS

Interest on investment (___%)	$ 550 /month	
Yard cost	640	
Insurance	100	
Season mobilization	108	
Lay up (___ month/year)		
Supplies, hardware	1,790	
Repair and dry docking	160	
Total other ownership costs		$ 3,348

OTHER OPERATING COSTS

Fuel Cost 216 hours/month X 80 H.P. X .067 gallon/hour/H.P. X $ .65 /gallon =	$ 750 /month	
Water and lubricants	50	
Pipeline (50% of pipeline costs from Part III)		
Supplies, subsistance	910	
Total other operating costs		$ 1,710

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$	$	$
Shoreline			
Total			

Note: Assume ___ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	98	0	10	129	66		

DREDGING COST RATES FOR PLANT OPERATION

Small Dozer (JD450)

____inch Dredge 40 H.P. ____hour operation ____feet transit distance

(a) (b)

PART I

PAYROLL (Supervisor and Engineer)

	Monthly rate
____Project Manager	$____
____Superintendent	
____Captain	
____Chief Engineer	
____Civil Engineer	
____Office Personnel	
____Chief Surveyor	
____Surveyor	
____Inspector	
Subtotal	
Taxes, insurance and fringes (____%)	
Total	

PAYROLL (Operations, Dredging)

	Hourly rate
____Leverman	$____
____Watch Engineers, Strikers	
____Dredge Mates	
____Equipment Operators - Tender	
1 Equipment Operators - On land	7.60
____Welders	
____Oilers.	
____Deckhands.	
____Stewards	
____Mess Attendants	
____General Dump Foreman	
____Dump Foreman	
____Yard and Shoreman	
____Other ____________	
Subtotal	
Work ____ hours/week	
Pay ____ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (____%)	
Total	2,554 (2)

PAYROLL (Operations, Transit)

	Hourly rate
____Watch Engineers	$____
____Pilot	
____Dredge Mates	
____Tender Masters	
____Tender Operators	
____Tender Mates	
____Deckhands	
____Stewards	
____Mess Attendants	
____Yard and Shoremen	
Subtotal	
Work Hours Pay	
Pay ____ hours/week	
Monthly wages (4.34 weeks	
Taxes, insurance and fringes (____%)	
Total	____ (3)

PART II

OWNERSHIP AND OPERATION (____ month/year operation)

Plant	Value (estimate)	Life	Monthly costs
Dredge (____________)		____years	$____
Booster Dredge (________)			
____1,000 H.P. Tenders			
____400 H.P. Tenders			
____200 H.P. Tenders			
____Work barges			
____Equipment barges			
____Fuel-water barges			
____Belly anchor barges			
____Crew launch			
____Survey launch			
____Skiff and outboard			
____Hoist (____T.)			
____Derrick (____T.)			
1 Bulldozers	18,000	10	300
____Pickup trucks			
____Office barge (trailer)			
____Tractor/trailer			
Pipeline (50% of pipeline costs from Part III)			
Total depreciation			300

OTHER OWNERSHIP COSTS

Interest on investment (____%)	$ 330 /month	
Yard cost	384	
Insurance	100	
Season mobilization	110	
Lay up (____month/year)		
Supplies, hardware	1,074	
Repair and dry docking	96	
Total other ownership costs		$ 2,094

OTHER OPERATING COSTS

Fuel Cost

216 hours/month X

40 H.P. X

.067 gallon/hour/H.P. X

$ .65 /gallon = $ 376 /month

Water and lubricants	30	
Pipeline (50% of pipeline costs from Part III)		
Supplies, subsistance	910	
Total other operating costs		$ 1,316

PART III

PIPELINE COSTS

	Mud	Sand	Rock
Floating line	$____	$____	$____
Shoreline			
Total			

Note: Assume ____ working days per month. Enter monthly costs divided by working days in Part IV.

PART IV

DATA INPUTS

Variable	Subscripts (X) (1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
DREDGE (METHOD, RANGE, X)	0	98	0	12	81	51		

Equipment	Replacement cost used	Updated replacement cost
20-inch dredge	$9,450,000	$9,450,000
16-inch dredge	6,615,000	6,615,000
12-inch dredge	2,175,000	3,750,000
8-inch Mudcat	110,000	110,000
20-inch booster	3,780,000	3,780,000
16-inch booster	2,646,000	2,646,000
12-inch booster	870,000	1,250,000
Bucket-chain dredge (600 cu yd/hr)	3,260,000	3,260,000
Bucket-chain dredge (250 cu yd/hr)	1,171,000	1,171,000
Backhoe (350 hp)	600,000	900,000
Backhoe (750 hp)	1,355,000	1,500,000
Clamshell (350-hp)	600,000	900,000
Clamshell (750-hp)	1,350,000	1,500,000
4,000-hp tender	3,500,000	3,500,000
2,000-hp tender	2,000,000	2,000,000
1,000-hp tender	428,000	600,000
1,000 cubic yard deck barge	800,000	800,000
175 cubic yard deck barge	200,000	200,000
Work barges	160,000	120,000
Equipment barges	200,000	225,000
Fuel barges	250,000	275,000
Swing anchor barges	10,000	70,000
Crew launch	8,000	8,000
Survey launch	280,000	150,000
Bulldozer (130-hp)	55,000	155,000
Bulldozer (80-hp)	30,000	60,000
400-hp tender	330,000	375,000
200-hp tender	180,000	200,000

Comparison of replacement costs

The following table shows the staff and equipment which made up each dredging plant and portion of a full dredging plant in some cases.

Summary of staff and component equipment

Payroll (supervisor, engineer)

Equipment	Distance to placement (feet)	Project manager	Superintendent	Captain	Chief engineer	Civil engineer	Office personnel	Chief surveyor	Surveyor	Inspector
Dredge										
20-inch pipeline	1800	-	1	1	1	1	1	1	1	1
20-inch pipeline	2800	-	1	1	1	1	1	1	1	1
20-inch pipeline	4400	-	1	1	1	1	1	1	1	1
20-inch pipeline	8000	-	1	1	1	1	1	1	1	1
16-inch pipeline	1700	-	1	1	1	1	1	1	1	1
16-inch pipeline	2400	-	1	1	1	1	1	1	1	1
16-inch pipeline	3500	-	1	1	1	1	1	1	1	1
16-inch pipeline	6000	-	1	1	1	1	1	1	1	1
16-inch pipeline	8500	-	1	1	1	1	1	1	1	1
12-inch pipeline	1500	-	.5	-	1	1	.5	.5	.5	1
12-inch pipeline	2500	-	.5	-	1	1	.5	.5	.5	1
12-inch pipeline	4000	-	.5	-	1	1	.5	.5	.5	1
12-inch pipeline	6500	-	.5	-	1	1	.5	.5	.5	1
8-inch Mudcat	2500	-	-	.5	-	-	.5	.5	.5	1
8-inch Mudcat	5200	-	-	.5	-	-	.5	.5	.5	1
8-inch Mudcat	7000			.5			.5	.5	.5	1
Pneuma	2000			.5			.5	.5	.5	1
Pneuma	4000			.5			.5	.5	.5	1
Pneuma	6000			.5			.5	.5	.5	1
Mechanical dredge	**Size**									
Clamshell dredging	250 hp	-	.5	-	1	1	.5	.5	.5	1
Clamshell dredging	800 hp	-	1	1	1	1	1	1	1	1
Bucket-chain dredging	250 hp	-	.5	-	1	1	.5	.5	.5	1
Bucket-chain dredging	800 hp	-	1	1	1	1	1	1	1	1
Backhoe dredging	250 hp	-	.5	-	1	1	.5	.5	.5	1
Backhoe dredging	800 hp	-	1	1	1	1	1		1	1
Clamshell - unload barges	250 hp									
Clamshell - unload barges	800 hp									
Backhoe - unload barges	250 hp									
Backhoe - unload barges	800 hp									

Payroll (operations, dredging)

Equipment	Distance to placement (feet)	Leverman	Watch engineers Strikers	Dredge mates	Equipment operator tender	Equipment operator on land	Welders	Oilers	Deckhands	Stewards	Mess attendants	General dump foreman	Dump foreman	Yard and shoreman	Other
Dredge															
20-inch pipeline	1800	3	3	3	2	2	2	-	8	1	3	-	-	-	-
20-inch pipeline	2800	3	3	6	2	2	2	-	12	1	3	1	-	8	-
20-inch pipeline	4400	3	3	6	2	2	2	-	14	1	3	1	-	8	-
20-inch pipeline	8000	3	3	6	4	2	2	-	14	1	3	1	-	8	-
16-inch pipeline	1700	3	2	2	2	2	1	-	8	-	-	1	-	6	-
16-inch pipeline	2400	3	2	4	2	2	2	-	10	-	-	1	-	6	-
16-inch pipeline	3500	3	2	4	2	2	2	-	12	-	-	1	-	6	-
16-inch pipeline	6000	3	2	4	3	2	2	-	12	-	-	1	-	6	-
16-inch pipeline	8500	3	2	4	5	2	2	-	12	-	-	1	-	6	-
12-inch pipeline	1500	3	22	2	1	2	1	-	4	-	-	1	-	4	-
12-inch pipeline	2500	3	2	2	2	2	1	-	6	-	-	1	-	4	-
12-inch pipeline	4000	3	2	2	3	2	2	-	8	-	-	1	-	4	-
12-inch pipeline	6500	3	2	3	3	2	2	-	10	-	-	1	-	4	-
8-inch Mudcat	2500	2	-	2	-	2	-	-	4	-	-	-	-	2	-
8-inch Mudcat	5200	2	-	2	-	[illegible]	-	-	6	-	-	-	-	2	-
8-inch Mudcat	7000	2		2		6	-		8	-	-	-	-	2	-
Pneuma	2000	3	2	2	1	2	-	1		-	-	-	-	4	-
Pneuma	4000	3	2	2	1	2	-	1		-	-	-	-	4	-
Pneuma	6000	3	2	2	1	2	-	1		-	-	-	-	4	-
Mechanical dredge	**Size**														
Clamshell dredging	250 hp	3	2	2	3	-	-	2	4	-	-	-	-	-	-
Clamshell dredging	800 hp	3	2	2	4	-	3	2	4	-	-	-	-	-	-
Bucket-chain dredging	250 hp	3	2	2	2	-	-	-	4	-	-	-	-	-	-
Bucket-chain dredging	800 hp	3	2	2	2	-	1	-	4	-	-	-	-	-	-
Backhoe dredging	250 hp	3	2	2	3	-	-	2	4	-	-	-	-	-	-
Backhoe dredging	800 hp	3	2	2	4	-	2	2	4	-	-	-	-	-	-
Clamshell - unload barges	250 hp	-	2	-	2	4	1	2	4	-	-	1	-	-	-
Clamshell - unload barges	800 hp	-	2	-	4	8	1	2	4	-	-	1	-	2	-
Backhoe - unload barges	250 hp	-	2	-	2	4	1	2	4	-	-	1	-	-	-
Backhoe - unload barges	800 hp	-	2	-	4	8	1	2	4	-	-	1	-	2	-

Payroll (operations, transit)

Equipment	Distance to placement (feet)	Watch engineers	Pilot	Dredge mates	Tender masters	Tender operators	Tender mates	Deckhands	Stewards	Mess attendants	Yard and shoremen
Dredge											
20-inch pipeline	1800	2	2	2	2	-	-	6	1	3	-
20-inch pipeline	2800	2	2	3	2	-	-	6	1	3	-
20-inch pipeline	4400	2	2	3	2	-	-	6	1	3	-
20-inch pipeline	8000	2	2	3	2	-	-	6	1	3	-
16-inch pipeline	1700	2	2	2	2	-	-	6	-	-	-
16-inch pipeline	2400	2	2	2	2	-	-	6	-	-	-
16-inch pipeline	3500	2	2	2	2	-	-	6	-	-	-
16-inch pipeline	6000	2	2	2	3	-	-	6	-	-	-
16-inch pipeline	8500	2	2	2	3	-	-	6	-	-	-
12-inch pipeline	1500	2	2	2	1	-	-	4	-	-	-
12-inch pipeline	2500	2	2	2	1	-	-	4	-	-	-
12-inch pipeline	4000	2	2	2	2	-	-	6	-	-	-
12-inch pipeline	6500	2	2	2	2	-	-	6	-	-	-
8-inch Mudcat	2500	-	+	2	-	2	-	4	-	-	-
8-inch Mudcat	5200	-		2	-	2	-	4	-	-	-
8-inch Mudcat	7000			2		2		4			
Pneuma	2000	2	2	2	1			4			
Pneuma	4000	2	2	2	1			4			
Pneuma	6000	2	2	2	1			4			
Mechanical dredge	**Size**										
Clamshell dredging	250 hp	1	-	1	2	-	-	4	-	-	-
Clamshell dredging	800 hp	1	-	1	2	-	-	4	-	-	-
Bucket-chain dredging	250 hp	2	2	2	-	-	-	4	-	-	-
Bucket-chain dredging	800 hp	2	2	2	-	-	-	4	-	-	-
Backhoe dredging	250 hp	1	-	1	2	-	-	4	-	-	-
Backhoe dredging	800 hp	1	-	1	2	-	-	4	-	-	-
Clamshell - unload barges	250 hp	1	1	-	1	-	-	4	-	-	-
Clamshell - unload barges	800 hp	1	1	-	1	-	-	4	-	-	-
Backhoe - unload barges	250 hp	1	1	-	1	-	-	4	-	-	-
Backhoe - unload barges	800 hp	1	1	-	1	-	-	4	-	-	-

Ownership and operations

Equipment	Distance to placement (feet)	Plant	Booster	1,000-hp tenders	400-hp tenders	200-hp tenders	Work barges	Equipment barges	Fuel-water barges	Anchor barges	Crew launch	Survey launch	Skiff and outboard	Hoist (___ t)	Derrick (___ t)	Bulldozers (130)	Bulldozers (80)	Pickup trucks	Office barge	Tractor/trailer
Dredge																				
20-inch pipeline	1800	1	-	-	2	1	1	1	1	1	1	1	2	-	-	2	-	1	-	-
20-inch pipeline	2800	1	-	1	2	1	1	1	1	1	1	1	2	-	-	2	-	1	-	-
20-inch pipeline	4400	1	-	1	2	1	1	1	1	1	1	1	2	-	-	2	-	1	-	-
20-inch pipeline	8000	1	1	1	3	2	2	2	2	1	1	1	2	-	-	2	-	1	-	-
16-inch pipeline	1700	1	-	-	1	2	1	1	1	1	2	1	4	-	-	2	-	3	1	-
16-inch pipeline	2400	1	-	1	1	2	1	1	1	1	2	1	4	-	-	2	-	3	1	-
16-inch pipeline	3500	1	-	1	1	2	1	1	1	1	2	1	4	-	-	2	-	3	1	-
16-inch pipeline	6000	1	-	1	2	2	1	1	1	1	2	1	4	-	-	[illegible]	-	3	1	-
16-inch pipeline	8500	1	1	1	2	2	1	1	1	1	2	1	4	-	-	2	-	3	1	-
12-inch pipeline	1500	1	-	1	1	-	2	-	1	1	1	.5	2	-	-	-	2	22	11	-
12-inch pipeline	2500	1	-	1	1	-	2	-	1	1	1	.5	3	-	-	-	2	3	1	-
12-inch pipeline	4000	1	-	1	1	1	2	-	1	1	1	.5	5	-	-	-	2	4	1	-
12-inch pipeline	6500	1	1	1	1	1	2	-	1	1	1	.5	5	-	-	-	2	4	1	-
8-inch Mudcat	2500	1	-	-	-	1	1	-	-	-	-	.25	4	-	-	-	1	22	1	2
8-inch Mudcat	5200	1	2	-	-	1	1	-	-	-	-	.25	4	-	-	-	1	4	1	3
8-inch Mudcat	7000	1	4			1	1					.25	4				1	6	1	3
Pneuma	2000	1		1	1		1		1	1		.5	2				2	2	1	-
Pneuma	4000	1	1	1	1		2		1	1		.5	2				2	2	1	-
Pneuma	6000	1	2	1	1		3		1	1		.5	2				2	2	1	-
Mechanical dredge	**Size**																			
Clamshell dredging	250 hp	1	-	1	-	1	2	1	1	-	1	.5	3	-	-	-	-	-	1	-
Clamshell dredging	800 hp	1	-	1	1	-	2	2	1	-	1	.5	4	-	-	-	-	-	1	-
Bucket-chain dredging	250 hp	1	-	1	-	-	1	-	1	2	1	.5	1	-	-	-	-	-	-	-
Bucket-chain dredging	800 hp	1	-	1	-	-	1	-	1	2	1	1	2	-	-	-	-	-	-	-
Backhoe dredging	250 hp	1	-	1	-	1	2	1	1	-	1	.5	3	-	-	-	-	-	1	-
Backhoe dredging	800 hp	1	-	1	1	-	2	2	1	-	1	.5	4	-	-	-	-	-	1	-
Clamshell - unload barges	250 hp	1	-	-	1	-	1	1	1	-	1	-	4	-	-	[illegible]	2	2	1	-
Clamshell - unload barges	800 hp	1	-	-	2	-	1	1	1	-	1	-	5	-	-		-	4	1	-
Backhoe - unload barges	250 hp	1	-	-	1	-	1	1	1	-	1	-	4	-	-	-	2	2	1	-
Backhoe - unload barges	800 hp	1	-	-	2	-	1	1	1	-	1	-	5	-	-	4	-	4	1	-

Equipment		Payroll (supervisor, engineer)									Payroll (operations, dredging)			Payroll (operations, transit)										Ownership and operations		
Barges per Tow	Cubic yards per barge	Project managers	Superintendent	Captain	Chief engineer	Civil engineer	Office personnel	Chief surveyor	Surveyor	Inspector	Pilot	Deckhands	Engineers	Watch engineers	Pilot	Dredge mates	Tender masters	Tender operators	Tender mates	Deckhands	Stewards	Mess attendants	Yard & shoremen	Towboats	Barges	
1	175										2	4	.5											1	1	1,000-hp towboat
2	175										2	6	.5											1	2	
4	175										2	6	.5											1	4	
1	1,000										2	4	1											1	1	2,000-hp towboat
2	1,000										2	6	1											1	2	
4	1,000										2	6	1											1	4	
6	1,000										2	6	1											1	6	
9	1,000										2	6	1											1	9	4,000-hp towboat
12	1,000										2	6	1											1	12	

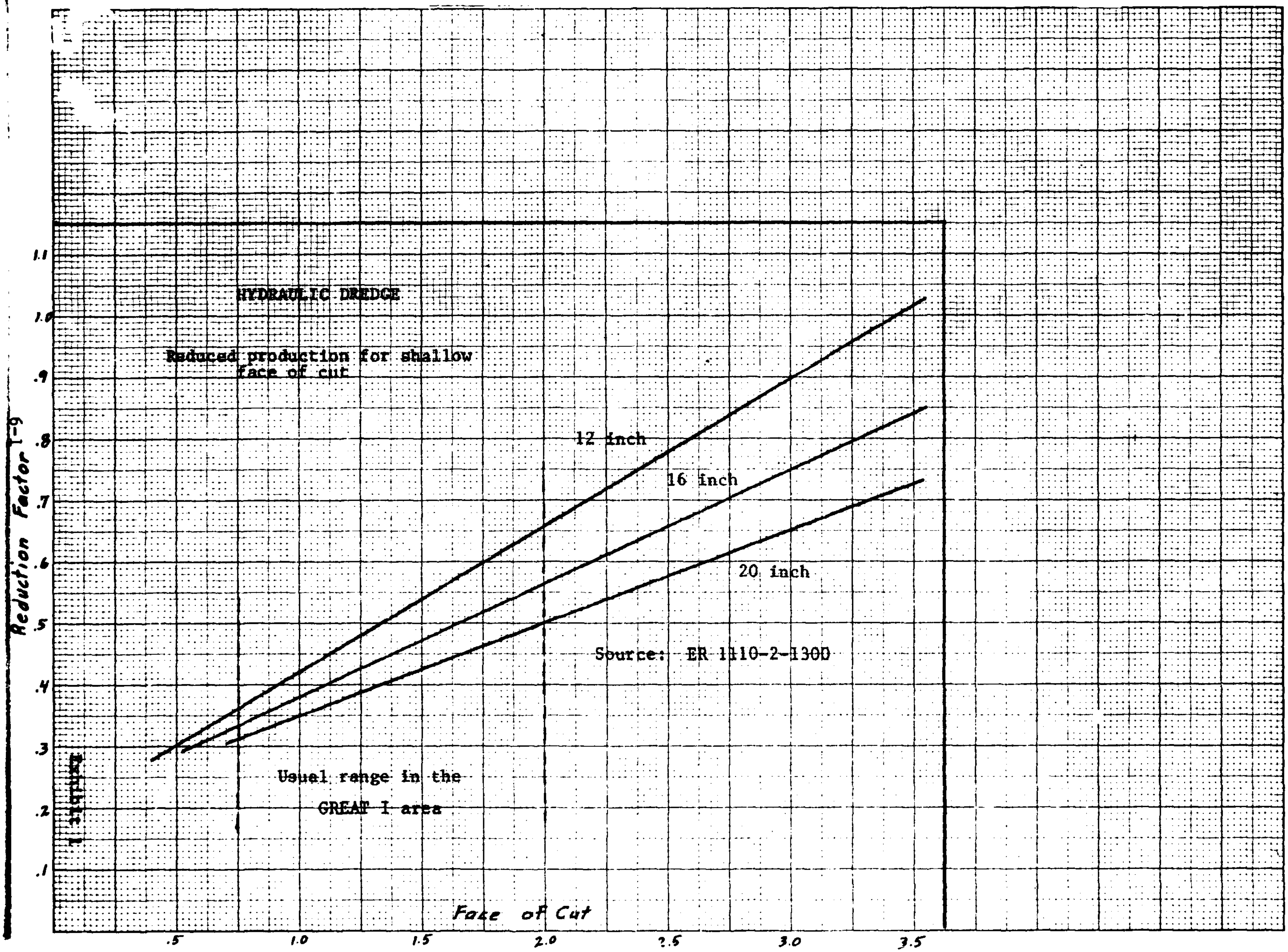
ATTACHMENT 6

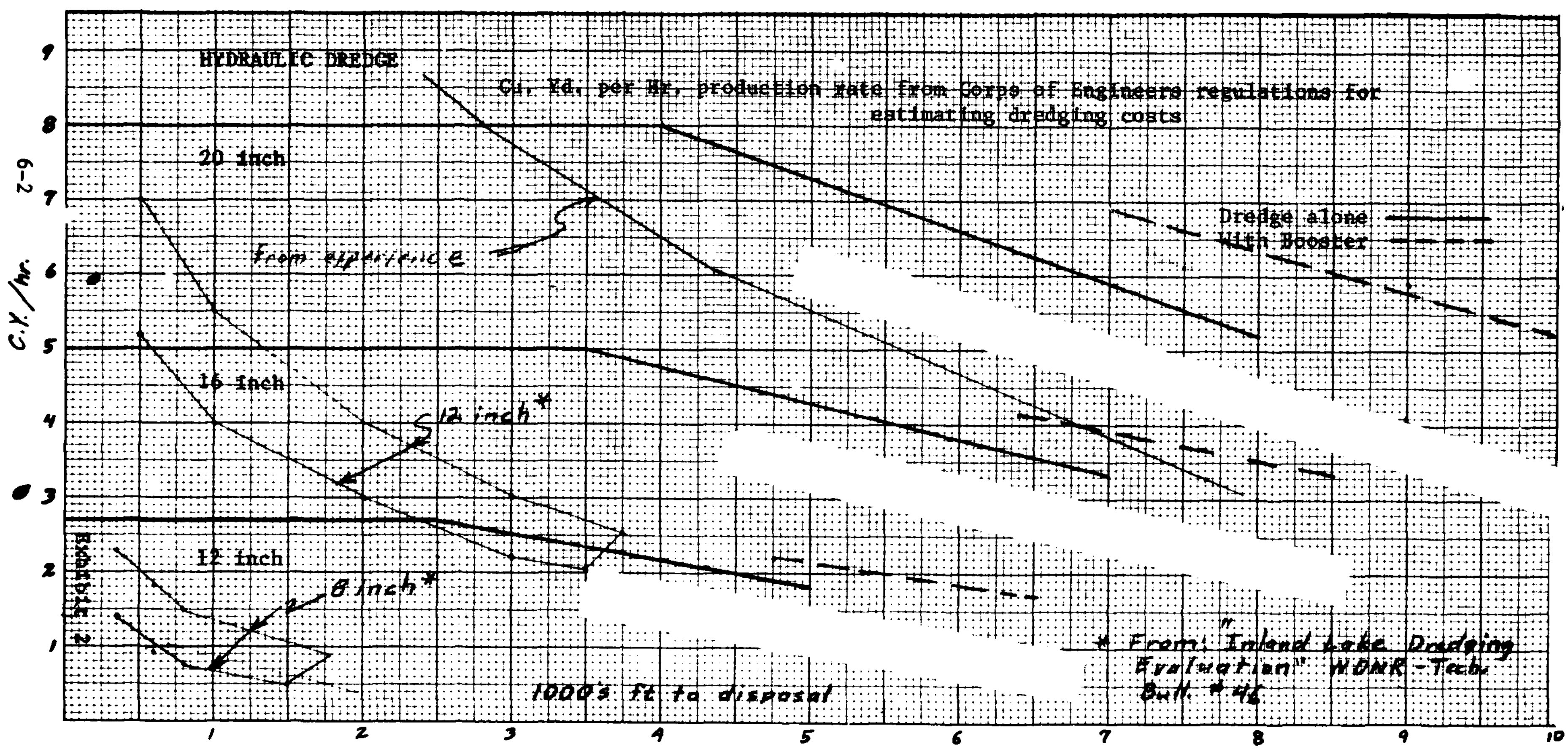
PHOTOGRAPHS AND EXHIBITS

ATTACHMENT 6

PHOTOGRAPHS AND EXHIBITS

TABLE OF CONTENTS


HYDRAULIC DREDGE
Reduced production for shallow face of cut
12 inch
16 inch
20 inch
Source: ER 1110-2-1300
Usual range in the GREAT I area
Exhibit 1
Reduction Factor
1.1
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
Face of Cut
.5
1.0
1.5
2.0
2.5
3.0
3.5


HYDRAULIC DREDGE
Cu. Yd. per Hr. production rate from Corps of Engineers regulations for estimating dredging costs
20 inch
16 inch
12 inch
From experience
12 inch*
8 inch*
Dredge alone
With Booster
* From: "Inland Lake Dredging Evaluation" WDNR - Tech. Bull. #46
C.Y./hr.
1000's ft to disposal
Exhibit 2

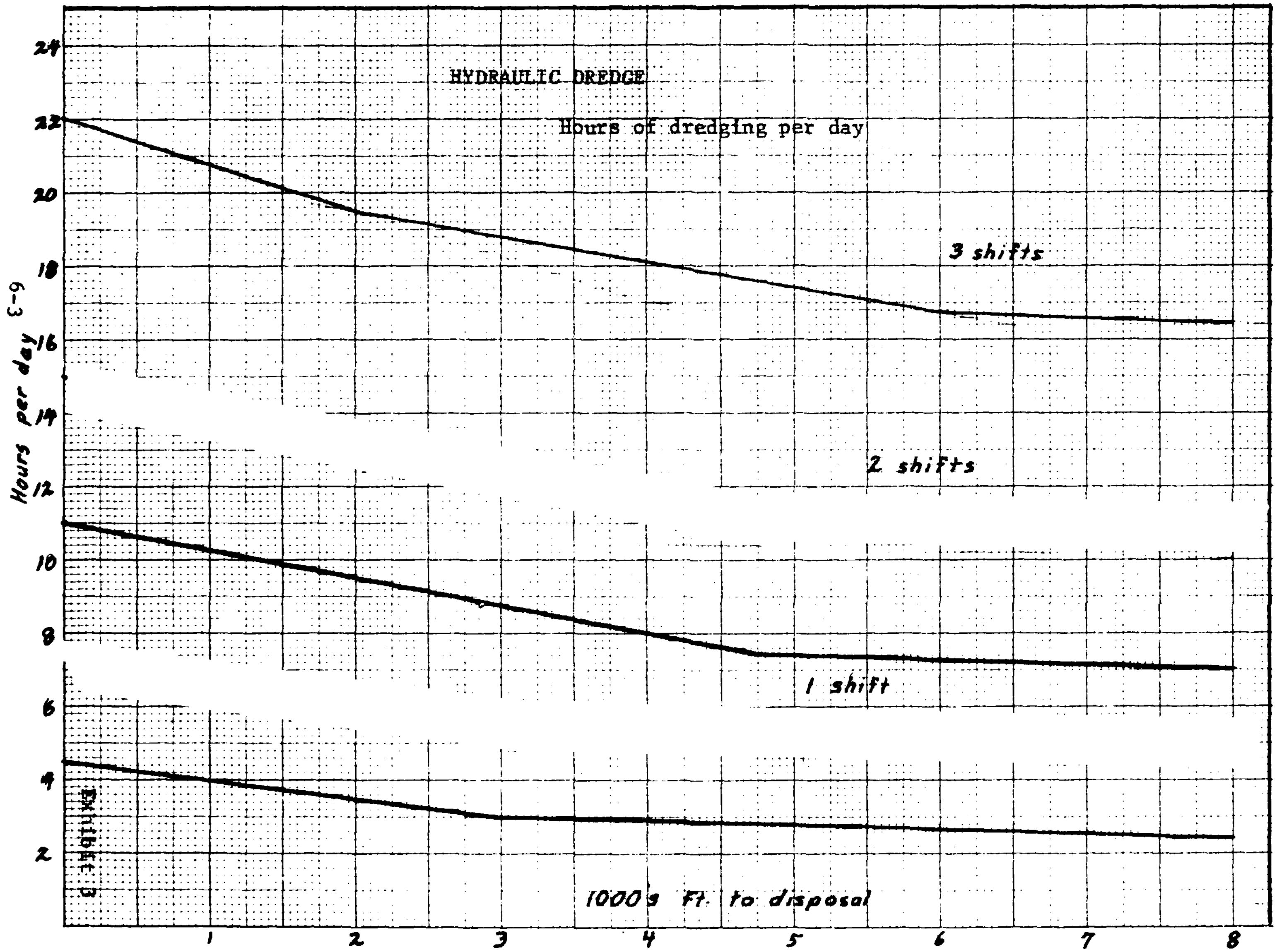

HYDRAULIC DREDGE
Hours of dredging per day
3 shifts
2 shifts
1 shift
Hours per day
1000's Ft. to disposal
24
22
20
18
16
14
12
10
8
6
4
2
1
2
3
4
5
6
7
8

Exhibit 3

SAMPLE OUTPUT FOR PLAN FORMULATION COST ESTIMATING PROGRAM

```
DO YOU WANT JUST THE SITE SUMMARY RATHER THAN THE DETAILED PRINTOUT?
I>N
TYPE IN IDENTIFYING NAME FOR CUT AND DISPOSAL SITE:

I>TEST FOR APPENDIX
DATA INPUT:

  POOL:            EXAMPLES:   03 FOR POOL 3
                               MN FOR MINNESOTA RIVER
                               SC FOR ST. CROIX RIVER
I>01

  RETENTION TIME IN DAYS:
I>0

  CUBIC YARDS DREDGED:
I>10000

  FREQUENCY OF DREDGING:
I>50

  DISTANCE TO DISPOSAL SITE IN FEET:
I>5000

  HOW HIGH IS DISPOSAL SITE
  ABOVE LOW CONTROL POOL ELEVATION?
I>10

  IS DIKING NEEDED?
I>N

  IS BERMING NEEDED?
I>N

  MAXIMUM HEIGHT OF DIKE OR BERM ALLOWED:
I>20

  IS RESHAPING FOR RECREATION OR
  OTHER USE REQUIRED?
I>N

  IS TRUCKING NECESSARY?
I>N

  IS ANY SPECIAL CONSTRUCTION REQUIRED?
I>N


     TEST FOR APPENDIX                                           PAGE 1
                                                               09-17-79


FOR 20-INCH HYDRAULIC DREDGE:

  BOOSTER NEEDED, WE HAVE ENOUGH PIPE,
  DREDGING TAKES  4. DAYS, AND COSTS $   27126.58 DREDGE IN
  USE 13. HOURS A DAY.

  THE DISPOSAL SITE COVERS  1. ACRES AND
  IS 6. FT. HIGH.  OVER THE 40 YEAR STUDY
  PERIOD THE PILE WILL COVER 11. ACRES
  AND BE 17. FT. HIGH.


  TOTAL COST OF DREDGING THE SITE IS $   27126.58
  AVERAGE ANNUAL COST IS $   14925.59
```

EXHIBIT 4

SAMPLE OUTPUT FOR PLAN FORMULATION COST ESTIMATING PROGRAM


```
FOR 12-INCH HYDRAULIC DREDGE:

  CALLS FOR BATHTUBBING THE MATERIAL, DREDGING INTO THE
  INTERMEDIATE SITE TAKES  7. DAYS, AND COSTS    17631.98 DREDGE IN
  USE 12. HOURS A DAY.

  LOADING THE MATERIAL INTO BARGES FROM THE INTERMEDIATE SITE COSTS
  $  19200.00 MOVING THE LOADED BARGES TO THE REHANDLING SITE
  COSTS $     3934.47

IS THIS BARGED MATERIAL TO BE REHANDLED IN THE WATER?
I>Y

HOW FAR INLAND IS THE DISPOSAL SITE?
I>500

THE 12-INCH DREDGE CAN PUMP     3953. CUBIC YARDS PER DAY INTO THIS SITE
WHICH IS FASTER THAN THE HAUSER AND WADE, WORKING TOGETHER CAN LOAD
THE BARGES FROM THE INTERMEDIATE SITE

IF THE BARGES COULD BE LOADED FASTER, THE 12-INCH DREDGE COULD UNLOAD
THE BARGES IN *** DAYS AT A COST OF $       2.53
IF THE BARGES MUST BE LOADED AT THE INTERMEDIATE SITE WITH A CLAMSHELL
UNLOADING THE BARGES AT THE REHANDLING SITE WITH A 12-INCH DREDGE
COSTS $    6817.50 AND TAKES  4. DAYS.

  THE DISPOSAL SITE COVERS  1. ACRES AND
  IS 6. FT. HIGH.  OVER THE 40 YEAR STUDY
  PERIOD THE PILE WILL COVER 11. ACRES
  AND BE 17. FT. HIGH.


  TOTAL COST OF DREDGING THE SITE IS $    47583.96
  AVERAGE ANNUAL COST IS $    26181.64
```



```
FOR CLAMSHELL DREDGE:


  DREDGING THE RIVER AND PLACING THE MATERIAL ON BARGES
  COSTS $  19200.00.  MOVING THE BARGES TO THE DISPOSAL SITE COSTS
  $    3934.47, (THIS VALUE MAY CHANGE).

IS THIS BARGED MATERIAL TO BE REHANDLED IN THE WATER?
I>Y

HOW FAR INLAND IS THE DISPOSAL SITE?
I>500

THE 12-INCH DREDGE CAN PUMP     3953. CUBIC YARDS PER DAY INTO THIS SITE
WHICH IS FASTER THAN THE HAUSER AND WADE, WORKING TOGETHER CAN LOAD
THE BARGES FROM THE INTERMEDIATE SITE

IF THE BARGES COULD BE LOADED FASTER, THE 12-INCH DREDGE COULD UNLOAD
THE BARGES IN *** DAYS AT A COST OF $       2.53
IF THE BARGES MUST BE LOADED AT THE INTERMEDIATE SITE WITH A CLAMSHELL
UNLOADING THE BARGES AT THE REHANDLING SITE WITH A 12-INCH DREDGE
COSTS $    6817.50 AND TAKES  4. DAYS.
  THE TOTAL COST OF THE CLAMSHELL DREDGING OPERATION ALONE
  IS $  32959.97.  THE COSTS OF LOADING THE BARGES, MOVING
  THE BARGES AND UNLOADING BY CLAMSHELL ARE BASED ON "PER CUBIC YARD"
  FACTORS RATHER THAN EQUIPMENT OPERATING COSTS.
```

EXHIBIT 4 (CONT)

```
IS A LOCKAGE NECESSARY?
```

ST PAUL DISTRICT NOW HAS 6 BARGES CAPABLE OF DUMPING: 1- 175 CY HYDROCLAP, 2- 165 CY SIDE DUMP, 1-110 CY SIDE DUMP & 2- 225 CY, BOTTOM DUMP SCOWS

2 SCOWS AND 1 TENDER USED

A ROUGH ESTIMATE OF DAYS TO DREDGE THIS SITE IS, 6.7 DAYS FOR A ONE-SHIFT OPERATION, 3.3 DAYS FOR A TWO-SHIFT OPERATION, AND 2.2 DAYS FOR A THREE-SHIFT OPERATION.

THE DISPOSAL SITE COVERS 1. ACRES AND IS 6. FT. HIGH. OVER THE 40 YEAR STUDY PERIOD THE PILE WILL COVER 11. ACRES AND BE 17. FT. HIGH.

TOTAL COST OF DREDGING THE SITE IS $ 32959.97
AVERAGE ANNUAL COST IS $ 18135.24

```
 XXXX  X XXXXXXX XXXXX    XXXX X   X X    X X    X  XXX  XXXX  X   X
X      X    X    X       X     X   X XX  XX XX  XX X   X X   X  X X
 XXX   X    X    XXX      XXX  X   X X XX X X XX X X   X XXXX    X
    X  X    X    X           X X   X X    X X    X XXXXX X  X    X
XXXX   X    X    XXXXX   XXXX   XXX  X    X X    X X   X X   X   X
```

TEST FOR APPENDIX 09-17-79

CONDITIONS:

DREDGE CUT	DISPOSAL SITE
10000. CU YDS DREDGED	0 DAYS RETENTION
50.% FREQUENCY	10. FT ABOVE LCP ELEV
5000. FT TO DISPOSAL SITE	20. FT MAX DIKE OR PILE HEIGHT
	NO DIKING OR BERMING

SPECIAL CONDITIONS:
MATERIAL IS REHANDLED IN THE WATER

DREDGE TYPE:	TOTAL COST	UNIT COST	AVERAGE ANNUAL COST	DIKING COSTS
HYDRAULIC:				
20-INCH	$ 27126.58	$ 2.71	$ 14925.59	$ 0.00
16-INCH				
12-INCH	$ 47583.96	$ 4.76	$ 26181.64	$ 0.00
MUDCAT				
MECHANICAL:				
CLAMSHELL	$ 32959.97	$ 3.30	$ 18135.24	$ 0.00
LADDER-BUCKET				
PNEUMA				

	DAYS USED	EQUIP. NEEDED	SIZE OF DIKE AREA	SIZE OF DIKE HEIGHT	40-YEAR DIKE AREA	40-YEAR DIKE HEIGHT
HYDRAULIC:						
20-INCH	4.		1. A.	6. FT.	11. A.	17. FT.
16-INCH						
12-INCH	7.		1. A.	6. FT.	11. A.	17. FT.
MUDCAT						
MECHANICAL:						
CLAMSHELL	3.		1. A.	6. FT.	11. A.	17. FT.
LADDER-BUCKET						
PNEUMA						

EXHIBIT 4 (CONT)

DEPARTMENT OF THE ARMY
Office of the Chief of Engineers
Washington, D. C. 20314

ER 1110-2-1300

DAEN-CWE-BA

Regulation
No. 1110-2-1300

15 February 1978

Engineering and Design
GOVERNMENT ESTIMATES AND HIRED LABOR ESTIMATES FOR DREDGING

1. Purpose. The purpose of this regulation is to provide the estimator with general data, procedures, average values, and a format for guidance in preparing Government estimates and hired labor estimates for hopper dredging and hydraulic pipeline dredging. This regulation also outlines the procedure required to determine the total contract costs, or the total hired labor costs.

2. Applicability. This ER applies to all field operating agencies who are required to prepare Government estimates or hired labor estimates for new work or maintenance dredging.

3. References.

a. 33 U.S.C. 624

b. ER 1125-2-312

c. ER 1130-2-307

d. ER 1180-1-1, (ECI 1-372)

4. Definitions.

a. Government estimates, as used in this regulation, refers to the estimate of fair and reasonable cost to the contractor (without profit) which is prepared for the purpose of evaluating bids.

b. A hired labor estimate is prepared for the purpose of determining the cost of performing the work by Government plant and hired labor, and in those cases where the work has been advertised, it is used as a basis for comparison with the low bid contract price in accordance with 33 U.S.C. 624 and paragraph 1-372 (g), of ER 1180-1-1.

5. General.

a. In addition to pipeline dredge and hired labor hopper dredge estimates, this estimating procedure will also be used for side casting dredges

This regulation supersedes para 17c and APP I, ER 1130-2-307, 31 Oct 68.

with the appropriate changes in production and direct cost items of Appendix A, and for bucket dredges with modifications to Appendix B. The term pipeline dredges is understood to include cutterhead, plain suction, and dustpan dredges. Associated work items such as clearing and grubbing, dike construction, disposal area maintenance, drilling and blasting and environmental protection will not be included in the dredging estimate format, but will be estimated separately in the same manner as other Civil Works construction, and included in the appropriate bid item of the estimate.

b. The sample estimating formats of Appendixes A and B were developed to provide the estimator with procedures to prepare estimates from the data available for the proposed work. Format departures and changes are permitted, if required or desirable in the opinion of the estimator. When major changes in format, other than those required to adapt the format to a specific type dredge plant, are required, HQDA (DAEN-CWE-BA) WASH DC 20314 is to be advised of the change so that other divisions and districts can be made aware of the need for deviation.

c. To reduce the bulk of the estimate to a minimum and to provide a common basis for comparison all repetitive data may be combined in a "back-up" file. This file will be periodically updated as needed, but on an annual basis as a minimum. The Division Engineer should monitor the cost data to ensure that the data is being properly maintained on a current basis, and that the costs used are reasonably consistent throughout the division.

d. Estimates should be based on cost without profit using current cost data. Job requirements should be carefully analyzed and evaluated by an experienced Corps engineer with a background in dredging. Completed estimates should be reviewed for accuracy and completeness by an employee with dredging experience to reduce the possibility of errors and omissions and to assure reasonable judgments where judgmental factors are involved. Current cost data should be maintained by correspondence with competent sources, as opposed to verbal contacts, and by careful analysis of completed comparable work.

e. Estimates of jobs actually performed can serve as a reference for future estimates, especially for recurring assignments. For an estimate to serve as a reference, it is necessary to compare it with actual job performance.

6. Submission and Approval. In cases where the estimated total job cost (dredging, plus mobilization and demobilization, plus any associated work) exceeds the authority of the District Engineer, the estimate

for Civil Works projects will be submitted to the Division Engineer for approval not later than 10 days prior to the scheduled opening of bids or commencement of negotiations. All hired labor estimates for the Industry Capability Program must have approval of the Division Engineer prior to opening bids. Estimates shall be forwarded by letter, containing the name of the project, the invitation number, and the bid opening date. The estimate shall be preceded by a narrative statement outlining pertinent information and the estimator's reasoning and major assumptions.

FOR THE CHIEF OF ENGINEERS:

3 Appendixes
APP A - Hired Labor Dredging Estimate Hopper Dredge
APP B - Hydraulic Pipeline Dredge Dredging Estimate
APP C - Instructions and Background Information for Completing Appendixes A and B

JAMES N. ELLIS
Colonel, Corps of Engineers
Executive Director, Engineer Staff

APPENDIX A
FORMAT

DREDGING ESTIMATE _ U.S. HOPPER DREDGE ____________________

DISTRICT:____________ DATE:____________ ESTIMATOR:__________ REVIEWER:______

INVITATION NO.________________________ BID ITEM NO. ________________________

PROJECT
____
____
____
____

EXCAVATION

(ALL QUANTITIES ARE CUBIC YARDS, IN PLACE)

REQUIRED ______________C.Y. DREDGING AREA __________SQ. FT.

PAY OVERDEPTH ______________C.Y. AVG. MAX. PAY DEPTH________FT.

MAX. PAY YARD. = ______________C.Y. AVG. NON-PAY DEPTH ________FT.

O.D. NOT DREDGED--______________C.Y. AVG. DEPTH O.D. NOT DREDGED________FT.

MATERIAL REMAINING -______________C.Y. (TOLERANCE)

NET PAY YARDAGE = ______________C.Y.

NON-PAY YARDAGE +______________C.Y.

GROSS YARDAGE = ______________C.Y.

PRODUCTION

TIME PER AVG. LOAD CYCLE: (INCLUDING CLEANUP)

(ALL QUANTITIES ARE C.Y., IN PLACE)

DREDGING ______________MIN. NUMBER OF LOADS/DAY ____________

TURNING +______________MIN. CUBIC YARDS/LOAD x ____________

TO DISPOSAL OR MOORING + ______________MIN. OPERATING DAYS/MO.x ____________

DUMPING OR PUMPOUT + ______________MIN. CUBIC YARDS/MONTH = ____________

TO DREDGING AREA + ______________MIN.

TOTAL =______________MIN.

GROSS YARD.______________ ÷ ______________C.Y./MO.=__________MO. (JOB DURATION)

A-1

FROM ENG FORM 22 (PLANT REPLACEMENT INCREMENT COST EXCLUDED, BUT INCLUDES OWNING DISTRICT O.H.)

DIRECT COST

DREDGE $__________/MO.__________

FLOATING PIPELINE +$__________/MO.__________

SUBMERGED PIPELINE +$__________/MO.__________

SHORELINE +$__________/MO.__________

ATTENDANT PLANT +$__________/MO.__________

ADJUSTMENTS TO FORM 22 ±$__________/MO.__________
(EXPLAIN)

MONTHLY COST = $__________/MO.__________

JOB DURATION X__________ MOS.__________

SUBTOTAL = $__________ __________

SPECIAL COSTS (EXPLAIN)+$__________ __________

TOTAL DIRECT COST =$__________ __________

••

INDIRECT COST

SURVEYS $__________ __________

SUPERVISION & INSPECTION$__________ __________

ENGINEERING & DESIGN +$__________ __________

OTHER +$__________ __________

OVERHEAD OPER. DIST.___%$__________ __________

TOTAL INDIRECT COST = $__________ __________

••

TOTAL DREDGING COST

TOTAL DIRECT COST $__________

TOTAL INDIRECT COST +$__________

INTEREST ON INVESTMENT IN GOVERNMENT PLANT +$__________

LIABILITY INS.(FED. COMP. ACT) 1.25% OF PAYROLL +$__________

RETIREMENT, HEALTH & LIFE INS. ____% OF BASE PAY +$__________

NET PAY YARDAGE COST =$__________

NET PAY YARD. COST $__________ ÷ NET PAY YARD.__________C.Y.=$__________/C.Y.

TOTAL DREDGING COST FOR BID SCHEDULE YARDAGE =

UNIT COST $______/C.Y. X MAX. PAY YARD.__________C.Y. =$__________

(ALL COSTS INCLUDE O.H.)

MOBILIZATION & DEMOBILIZATION

	# DAYS		$/DAY		TOTAL
MOBILIZATION OF DREDGE	______	X	______	=$	______
MOBILIZATION OF ATTENDANT PLANT	______	X	______	=$	______
PREPARE PLANT FOR WORK	______	X	______	=$	______
SUBTOTAL MOBILIZATION				=$	______
DEMOBILIZATION OF DREDGE	______	X	______	$	______
DEMOBILIZATION OF ATTENDANT PLANT	______	X	______	+$	______
LAYUP OF PLANT	______	X	______	+$	______
SUBTOTAL DEMOBILIZATION				=$	______
TOTAL MOBILIZATION & DEMOBILIZATION				=$	______

REMARKS

APPENDIX B
FORMAT

HYDRAULIC PIPELINE DREDGE - DREDGING ESTIMATE

DISTRICT:________ DATE:________ ESTIMATOR:________ REVIEWER:________

INVITATION NO:________ BID ITEM NO:________

PROJECT

EXCAVATION	REQUIRED	______ C.Y.	DREDGING AREA	______	SQ.FT.
	PAY OVERDEPTH	+ ______ C.Y.	AVG. MAX. PAY DEPTH	______	FT.
	MAX. PAY YARDAGE	= ______ C.Y.	AVG. NON-PAY DEPTH	______	FT.
	O.D. NOT DREDGED	- ______ C.Y.	AVG. DEPTH O.D. NOT DREDGED	______	FT.
	NET PAY YARDAGE	= ______ C.Y.			
	NON-PAY YARDAGE	+ ______ C.Y.			
	GROSS YARDAGE	= ______ C.Y.			

ASSUMED DREDGE SIZE______ INCH AVERAGE LENGTH OF PIPELINE______ FT.

	CHART PRODUCTION	______ C.Y./HR.	REMARKS
PRODUCTION	BANK FACTOR	X ______	______
	MATRL. FACTOR	X ______	______
	BOOSTER FACTOR	X ______	______
	OTHER FACTOR	X ______	______
	NET PRODUCTION	= ______ C.Y./HR.	

TIME	X ______ HRS/DAY	______
	X ______ DAYS/MO.	______

GROSS YARD.______ ÷ ______ C.Y./MO. = ______ MOS. NET JOB DURATION

CLEANUP + ______ MOS.

TOTAL JOB DURATION = ______ MOS.

BASIC PLANT	$__________ /MO.	__________	
FLOATING PIPELINE	+$__________ /MO.	__________	
SUBMERGED PIPELINE	+$__________ /MO.	__________	
SHORELINE	+$__________ /MO.	__________	
BOOSTER	+$__________ /MO.	__________	

COST (W/O PROFIT)

MONTHLY COST	=$__________ /MO.	__________	
JOB DURATION	X__________ MOS.	__________	
SUB-TOTAL	=$__________		
O.H.& BOND _____%	+$__________		
NET PAY YARDAGE COST	=$__________	:NET PAY YARD.__________	C.Y.=$______/CY

TOTAL DREDGING COST FOR BID SCHEDULE YARDAGE =

UNIT COST $________/C.Y. X MAX. PAY YARD.________________C.Y. = $__________

MOBILIZATION & DEMOBILIZATION

	# DAYS	$/DAY	TOTAL
MOBILIZE PLANT FOR TRANSFER	______ X	______	=$______
TRANSFER ALL PLANT_____MILES/DAY	______ X	______	=$______
PREPARE PLANT FOR WORK	______ X	______	=$______
SUBTOTAL MOBILIZATION			$______
DEMOBILIZE PLANT FOR TRANSFER	______ X	______	=$______
TRANSFER ALL PLANT_____MILES/DAY	______ X	______	=$______
PREPARE PLANT FOR LAY-UP	______ X	______	=$______
SUBTOTAL DEMOBILIZATION			$______

SUBTOTAL MOBILIZATION & DEMOBILIZATION $______

OVERHEAD & BOND _____% $______

TOTAL MOBILIZATION & DEMOBILIZATION $______

REMARKS

B-2

APPENDIX C

Instruction and Background Information
for Completing Appendixes A and B

This appendix defines and explains each entry on the dredging and mobilization and demobilization estimates on Appendixes A and B. That is, an estimator acquainted with this appendix should only require the appropriate information from the job to complete these estimates. Items of special cost to be included in the dredging and separate bid items such as shore work will require additional work sheets such as ENG Forms 1741, 1741 a. & 1741 b.

The following paragraphs are arranged to agree with the order of items on Appendixes A and B.

1. Project. Briefly describe the work to be accomplished. This description will state the dredging assignment, its station or shoal numbers, depth of required and allowable overdepth, other available pertinent data, and dredging, type of material to be dredged, including average in-place density, the estimator's reasoning, comments, and assumptions. (Use additional sheets if necessary).

2. Excavation. The items to be entered on Appendixes A or B are defined as follows:

a. The Required Excavation Yardage is the in-place volume (in cubic yards) of material to be removed from within the required pay prism including the allowable side slopes.

b. The Pay Overdepth yardage is the in-place volume (in cubic yards) of material between the required pay prism at the required depth elevation including the allowable side slopes, and the maximum pay prism at the overdepth elevation.

c. The Max. Pay Yardage is the sum of the required excavation and the pay overdepth yardages. This is the amount of material shown on the bid schedule.

d. The Pay Overdepth not Dredged yardage is the in-place volume (in cubic yards) of pay overdepth material that is estimated will not be dredged. [(1. - O.D. allowance in feet) x b.]

e. The Material Remaining (Tolerance) Yardage is the in-place volume (in cubic yards) of material lying within the required pay prism that is estimated will remain undredged, but will be acceptable because it is within the specified tolerance limits. (Generally only applicable to hopper dredging).

f. The Net Pay Yardage is the maximum pay yardage less the overdepth not dredged yardage less the material remaining (tolerance) yardage (c-d-e).

g. The Non-Pay Yardage is the in-place volume (in cubic yards) of material estimated to be removed from outside the maximum pay prism. [(k. ÷ O. D. allowance in feet) x b.]

h. The Gross Yardage is the sum of the net pay yardage and the non-pay yardage. (f+g)

i. The Dredging Area is approximately the area shown on the plans as requiring the removal of all material above the required grade elevation, including allowable side slopes. (Expressed in square feet).

j. The Average Maximum Pay Depth is the average thickness of material (in feet), existing above the pay overdepth grade. It is equal to the maximum pay yardage (in cubic feet) divided by the dredging area.

k. The Average Non-Pay Depth is the average thickness of material (in feet) estimated to be removed below pay overdepth grade.

l. The Average Depth of Pay Overdepth not Dredged is the average thickness of material (in feet) estimated to be remaining in the overdepth prism.

m. The estimated average non-pay depth is generally a function of the type of material to be dredged, the overdepth allowance in feet, and for hopper dredging, the control exercised in maintaining the depth of dragheads; for pipeline dredging, dredge size and depth of cutting banks are also factors. The non-pay yardage (item g) is estimated as a percentage of the pay overdepth yardage on the basis of the ratio of the average non-pay depth to the overdepth allowance in feet. Similarly, the pay overdepth not dredged yardage (item d) is also affected by the above factors and it is also estimated as a percentage of the pay overdepth yardage on the basis of the ratio of the average depth of pay overdepth not dredged to the overdepth allowance in feet. Generally, the percentage for computing the non-pay yardage is much greater than that for pay overdepth not dredged.

n. Where natural shoaling or scouring is expected to occur between the time of survey made prior to the bidding of the job and the survey to be made before commencement of dredging, and such shoaling or scouring is expected to be of such magnitude that it might affect the equitability of the unit cost of dredging notwithstanding any modification in contract price which is provided for in the "Variations in Estimated Quantities" provision in the specifications, then such shoaling or scouring should be duly considered, in the preparation of the plans and specification. It should be taken into account in the development of the bid schedule quantities in the specifications by adjusting the quantities to be dredged as computed from the prebidding survey to account for the shoaling or scouring. The net yardage resulting then becomes the bid schedule advertised quantity. In such cases, the specifications should clearly state that the quantity shown in the bid schedule includes an adjustment of a specified amount. Natural shoaling or scouring that may occur in an acceptance section during the period of operation of the dredge therein, ordinarily is not considered in the development of the estimate of gross quantity of material to be removed. However, if the District Engineer considers that the effect of such shoaling or scouring on the estimate would be significant, then in such particular case a realistic allowance of the yardage concerned may be provided for in the estimate of gross yardage. The format does not include this item because its use will be infrequent, however, in applicable cases this item should be inserted after non-pay yardage.

3. Hopper Dredge Estimates (Hired Labor).

a. Production. The rate of production depends on the particular dredge used as the basis for the estimate, the material to be dredged, the length of haul, the method of disposal (bottom dump or pumpout) and the estimated effective working time. The estimated production entered on Appendix A is in most instances the most important part of the estimate. That is, its significance generally outweighs that of many other factors in the estimate. Since it is difficult to estimate production purely on a theoretical basis, estimators must consider previous dredging records for the same or a similar assignment. Adjustments for the distance between the dredging and disposal areas and pipeline length (in case of pumpout) are in order. The experience of the owning District will be utilized in preparation of estimates. Previous performance experience on similar work, if available, will be provided as back up to the estimate. Cleanup operations should be included in the development of the time per average load cycle.

b. Direct Cost. Appendix A requires several monthly operating costs. These costs will include all costs for the dredge, and any other plant if used, for payrolls, operation, depreciation, fuel, water, lubricants, supplies, repair, drydocking, yard, insurance and the owning district's overhead. Current costs should be obtained from the dredge owning district as recorded on ENG Form 22. However, these costs as extracted from ENG Form 22 should be adjusted, if necessary, to provide for estimated increases in the cost of fuel, supplies, payrolls, repairs, etc., not previously anticipated and included in the current plant rates (Form 22). The format of Appendix A provides for such adjustments. The plant replacement increment item is not considered to be an element of cost in hired labor estimates and, therefore, must be excluded from the costs shown on ENG Form 22. Since current cost accounting regulations stipulate that overhead will not be applied to depreciation, the owning district should make sure that costs used or reported to borrowing districts meets this stipulation. The format also includes an item for any special costs peculiar to the job.

c. Indirect Cost. It is necessary to consider the following items of indirect cost in hired labor estimates so that the estimates will include all costs incurred by the Government in performing the work.

(1) A pro-rata share of land and dock support facilities and other items when they relate to the performance of work on a given project.

(2) Survey costs comparable to level of effort required when work is contracted, and performed by similar type plant. Survey costs include all expenditures for surveys immediately prior to, after and during the job, but the cost of surveys required for operational control during the course of the work performed by Corps plant will be considered a direct cost item. Costs for engineering and design and condition surveys leading to the job should not be included. Inspection and supervision and engineering and design costs include all expenditures directly related to performance of the dredging job. Overhead costs consist of the operating district's overhead percentage on the applicable indirect cost.

d. Total Dredging Cost. The sum of the total direct cost, the total indirect cost, the interest on the invested capital, the liability insurance, and any other cost directed by statute or administrative determination to be included in the estimate results in the overall cost of dredging the net pay yardage. The first two cost elements are outlined in the foregoing paragraphs b and c. The next two cost elements are to be included in the estimate as directed by paragraph 1-372 (f) of ER 1180-1-1. The cost charge for the interest on capital invested in Government plant (the remaining book value of the plant), except in case of leased plant, will be determined by a rate not in excess of the maximum prevailing rate being paid by the Government on current issues of bonds or other evidence of indebtedness. The cost charge of 1-1/4 percent of the amount of payrolls will be used to cover compensation for injuries to Government employees under the Federal Compensation Act. An element of cost in the last category which must be provided for in the estimate is in accordance with OMB circular A-76 as revised by Transmittal Memorandum No. 3. It stipulates that a factor should be added to reflect the full Government costs for retirement, health, and life insurance. This full cost factor amounts to 18.1 percent of base pay, and is made up of the following: Retirement, 14.1 percent; Health Insurance, 3.5 percent; Life Insurance, 0.5 percent. Only the difference between 18.1

percent and the percent for these same three items presently included in payroll costs as reflected on ENG Form 22, in accordance with existing cost accounting regulations will be the additional cost. Accordingly, a cost factor expressed as a percent of the base payroll will be included in the estimate as a cost item. No allowance for profit will be included in any hired labor estimate. The net pay yardage cost divided by the net pay yardage results in the estimated unit price. Since the Government estimate is based on the maximum pay yardage as indicated in the bid schedule, the unit price multiplied by this yardage results in the total estimated dredging cost to be entered on the bid schedule.

e. Mobilization and Demobilization. These costs should be shown separately for the dredge and attendant plant. In conventional hopper dredge operation utilizing bottom dumping and employing no attendant plant, there will be only one entry for mobilization of the dredge and the applicable overhead charge. Demobilization of the dredge normally becomes the mobilization for the next assignment. In developing mobilization and demobilization costs, it should be considered that reduced operating expenses may be applicable.

f. Total Hired Labor Cost. The sum of the total dredging costs plus mobilization and demobilization costs and any other costs associated with the dredging project that may be shown as separate items in the bid schedule, is the total hired labor cost to be compared with the low bid contract price as adjusted in accordance with paragraph 1-372(g) of ER 1180-1-1.

4. Pipeline Dredge Estimates.

a. Production. In order to estimate production, a dredge size must be assumed and the average length of pipeline must be determined. The dredge size depends mainly on availability, job duration, type of material, exposure to the elements, and capability of meeting specification minimum production requirements, or specified construction period. The production rate to be entered on Appendix B is in many instances the most uncertain part of the estimate. And because its significance in regard to cost and time and the range over which it can reasonably be assumed will outweigh any other assumption made in the estimate, it is discussed in some detail. The most reliable approach for estimating production rate is to base it on dredging records for the same or similar type work performed previously. If a production rate in cubic yards per hour or per month is available based on dredging records, it is entered on Appendix B under "Net production" or under "c.y./mo." and no other entries are required. However, the sources of the data shall be stated. If records are not available or applicable, a theoretical approach must be taken, and the production rate must be estimated. A procedure to achieve this is outlined in the following:

(1) Chart Production. Because of the complexity of the effects of pipeline size and length, these parameters cannot be considered in form of a simple multiplication factor. They are, therefore, considered in the following table which lists the average production rate for each size dredge for two critical pipe lengths based on pumping free flowing sand having insitu density of about 2,000 grams/liter and a cutting depth (bank height) equal to the cutter diameter. The pipe length to be used consists of the actual line length increased by "equivalent lengths" for fittings and rise of the discharge end of the piping above the waterline. The appropriate figure is entered in Appendix B and then modified by correction factors.

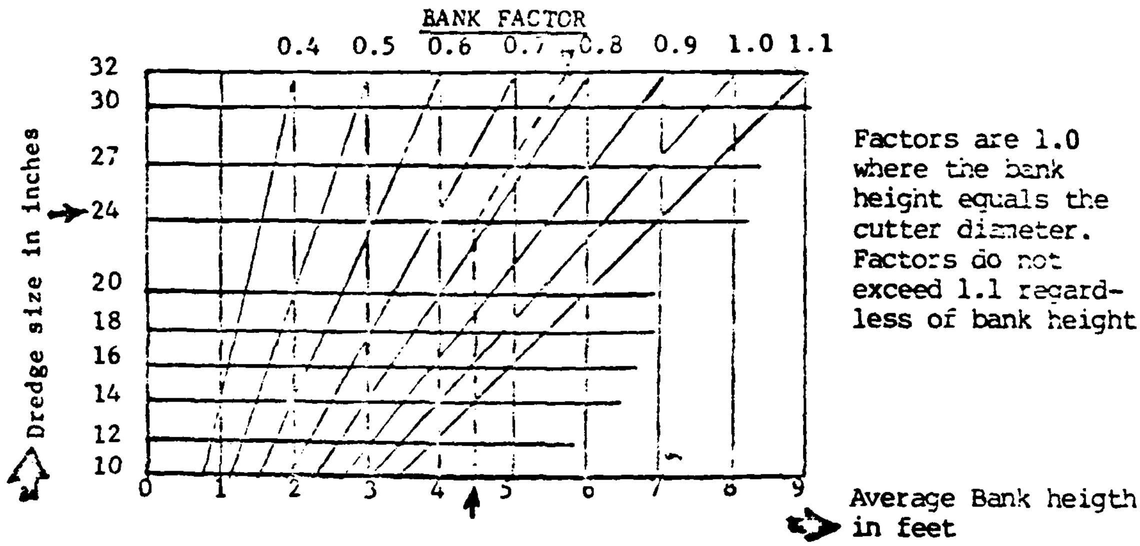
Hourly production as a function of line length

Dredge Size	Avg. H.P.	Up to this length	CY/HR	At this length	CY/HR
10"	500	2,000	200	4,000	130
12"	800	2,500	270	5,000	180
14"	1,200	3,000	380	6,000	250
16"	1,500	3,500	500	7,000	330
18"	1,800	4,000	650	8,000	420
20"	2,400	4,000	800	8,000	520
24"	4,000	5,000	1,200	10,000	780
27"	5,500	5,500	1,500	11,000	980
30"	7,000	6,000	1,800	12,000	1,170
32"	8,000	6,000	2,100	12,000	1,370

The significance of the two pipe lengths for each size dredge in the foregoing table is explained by the operation of a pipeline dredge. This operation is controlled by two different parameters as the discharge line length increases. For short lines the suction limitation holds the production rate constant. As the line length increases, more power is used until the maximum power is reach. From then on, the power limitation controls the production. That is, longer line lengths can only be achieved by a reduction in effluent velocity (assuming constant density). This continues until the velocity becomes so low that solids start to settle out. From this point on, longer line lengths are generally achieved by adding booster pumps.

The forgoing subparagraph shows that the operation of a cutterhead dredge is characterized by two points; namely, the transitions between the suction, power, and velocity limitation. The two-line lengths at which these transitions are expected to occur are listed on the foregoing table together with the expected production rates. As the foregoing subparagraph implies, the dredging rate is the same for all line lengths less than the shortest one listed irrespective of available pump power. The production between the two lengths listed will be interpolated.

(2) Bank Factor. Production in pipeline dredging is controlled either by the ability of the cutter to cut and the pump to transport the material or by the speed with which the dredge advances over the dredging area. The latter is frequently the criterion in shallow banks of easily dredged material. The factors in the following table are suggested to consider the effect of bank height.

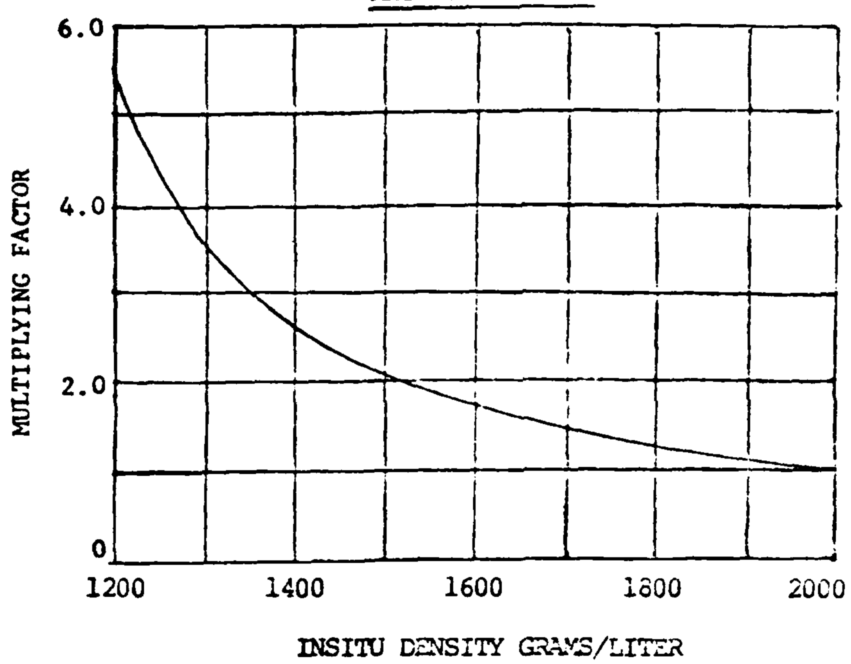


EXAMPLE: A 24-inch dredge with an average bank height of 4.5 feet. Projecting from the intersection of these two lines to the factor line at the top of the table would give a bank factor of about 0.78.

(3) Material Factor. The effect of the material to be dredged on production is very pronounced. Although its precise evaluation is difficult particularly since bottom material is generally not of uniform consistency or density and precise data pertaining thereto is usually lacking, its effect can be determined within an acceptable degree of

accuracy. Since the hourly production rates in the foregoing table are prepared for free-flowing sand, having an insitu density of about 2,000 grams/liter, these rates can be adjusted by a factor which considered the variations in the average insitu densities of different relatively free flowing materials such as mud, silt, sand or mixture thereof, the following chart gives the factor for different insitu densities. The chart is only for free flowing materials and must not be used for fat or stiff clay, heavy gravel, cobbles or broken stone. For the latter type materials experience on similar type work should be used.

MATERIAL FACTOR



(4) Booster Factor. Experience shows that the operation of booster pumps presents several problems. These problems are normally more acute when starting a job and subside somewhat with experience. To account for the reduced production caused by the introduction of boosters, multiplication factors are used. These factors are assumed to be 0.8 for each booster pump used for jobs of up to one month duration and 0.9 for longer lasting jobs.

(5) Other Factor. This entry on Appendix B is provided for a multiplication factor for any other correction in production not provided for in the foregoing, such as narrow channel (reduction), debris (reduction), ladder pump (15 to 30 percent increase), etc. If such a factor is used, it must be explained.

(6) Net Production. After all applicable factors are established, the product of all the factors is multiplied by the chart production and this product entered as net production. This net production constitutes the hourly dredging rate.

b. Time. Actual dredging times are less than 24 hours/day and 30 days/month.

(1) Actual dredging hours/day. Pumping interruptions associated with dredging operations such as handling pipelines, handling anchor lines, clearing pump or cutter head, changing location of plant on the job, passing vessels, minor operating repairs, refueling and waiting for attendant plant must be considered. To allow for these interruptions (exclusive of unfavorable weather) the number of daily operating hours (effective pumping time) is estimated. The rationale outlining this time estimate should be stated as a record in the event of a protest of the Government estimate.

(2) The number of operating days/month is less than the number of days in the month due to holidays, inclement weather, exposure, major breakdowns, major moves, and operating schedules less than 7 days per week. The rationale outlining this time estimate should be stated as a record in the event of a protest of the Government estimate.

(3) After the number of operating hours per day and number of operating days per month are established, they are multiplied with each other and the hourly net production to arrive at the monthly production. The gross yardage is then divided by this figure resulting in the number of months job duration which is also entered on Appendix B.

c. Cost (Hired Labor). If the pipeline dredge estimate is to be a hired labor estimate, the cost procedures described in paragraph 3 will be followed. The cost format of Appendix A (page A-2) will be used and the instructions pertaining thereto will be equally applicable.

d. Cost (Fair and Reasonable without Profit). If the pipeline dredge estimate is to be the "Fair and Reasonable without Profit" type, then the cost format of Appendix B will be used. The major items on this cost format are the monthly operating costs of the dredge, pipeline, and attendant plant, etc. These monthly operating costs must be developed by the estimator on the basis of the individual cost elements inherent in and associated with the ownership and operation of the specific items of plant and equipment. There is attached to this Appendix a suggested form, intended as a guide only, for developing these monthly operating costs. The Division Engineer may adopt the form as is or with such changes as deemed necessary or develop his own form which will contain the information to support the data used in the Cost Format of Appendix B. Division Engineers should develop and keep current by periodic updating a completed form for each size dredge commonly used on work in the division area. However, before data is extracted from a completed form, it should be reviewed and revised, as necessary, to assure that the data is current and applicable to the requirements and conditions of the particular job for which the cost estimate is being prepared. The estimator should assure himself that all applicable monthly costs have been included in the estimate. Normally, these monthly operating cost forms are a part of the back-up file. When they are revised for a particular job, a copy should be included in the estimate file for reference only, not as part of the Government estimate.

The first five entries in this part are monthly dredge operating costs. The sixth entry is the sum of the monthly operating costs, which is multiplied by the job duration. The product is entered on Appendix B as a subtotal.

The subtotal is then multiplied by a percentage for overhead and bond (normally 12 percent O.H. and 1 percent bond) and entered. The sum of the last two figures entered is the net pay yardage cost. This cost divided by the net pay yardage results in the unit price. Since the Government estimate (without profit) is based on the maximum pay yardage, the unit price multiplied by this yardage results in the Government estimate. The latter and the unit price are entered on the bid schedule.

The following comments pertain to the sample format at the end of this appendix. The costs on this format or format developed by the Division Engineer, will be reviewed before each job for which a Government estimate is being prepared, and at least annually, and necessary adjustments made.

(1) The payroll is divided into supervisory and operating crew costs. Pay rates for the crew should be based on prevailing Union rates for dredges 20" and over and dredges 18" and under. A prime source of wage rates are the weekly payrolls submitted by contractors on other contracts. It should be understood that the above source for wage rates will be used only if the wage rates actually paid are greater than the minimum wage rates indicated in the specifications.

(2) Taxes, insurance and fringe benefits for crewmen are estimated as a percentage of the total wages (including overtime). The tabulation below, shown only for illustrative purposes, depicts the method for deriving the necessary percentages. Each Division should determine the

correct percentages to use for the variable items by contacting the state department of labor for unemployment and workmans compensation and the union locals for the fringe benefits.

Social Security - 6.05 percent	1st $17,700	use -	6.05%
State unemployment comp. (Varies with each State)	- 4.5%	1st $4,200	
Federal unemployment comp.	- 0.5%*	1st $4,200	
	5.0%	1st $4,200	

Since the average annual salary is at least double the $4,200, say 50 percent of total payroll is subject to tax 50 percent x 5.0 percent — 2.50

Workmans compensation = (average) (Varies with state and contractor) — 12.65

Fringe benefits (vary with each union local agreement)

Vacation - (6% of straight time rate - $5.25) =	$0.32/hr.
Welfare	0.35/hr.
Pension	0.35/hr.
	$1.02/hr.

Total Fringes / Average hourly rate w/OT	$1.02 / $6.00 = 0.17	use	17.00
		TOTAL	38.20%

Some union local agreements include an hourly allowance for subsistence. If this is the case in your area, this cost should be included as part of fringe benefits.

(3) The number and size of attendant plant and size of crew will vary with the size of the dredges and the job conditions. This information should be derived from dredge reports on previous contracts.

(4) Depreciation is based on estimated original value of equipment, including additions and betterments, useful years of life, and six

*(Minimum is 0.5 percent, but will be increased to make up difference between the state and a minimum total of 3.2 percent)

months operation per year except where records and available data indicate that a greater figure is justified. For uniformity, the following useful life should be used:

Dredges -	10 through 14 inches	- 20 years
	16 through 20 inches	- 25 years
	24 inches and larger	- 30 years

The useful life for attendant plant will be generally as shown on the sample format.

(5) Interest on investment costs are computed in the following manner - Annual percent = R [N+1+ S(N-1)] - 2N, Where: R = the commercial interest rate. The current rate charged by lending companies is 11 percent, based on a banking prime rate of 9 percent plus 2 percent for private lender markup. N = the equipment life in years. S = salvage value expressed as a decimal. The average for dredge equipment should be .15 to .20. This annual cost will be divided by the assumed number of months of operation to arrive at the monthly cost.

(6) The fuel cost (Diesel) is based upon 0.5 lb. fuel or 0.067 gal. per h.p. per hour, the operating hours per month (operating hours/day X 25 days month), the current average fuel price and .85 operating power, assuming the plant is seldom operating at full power. The horsepower applied in this computation is the estimated average horsepower used by the dredge and attendant plant.

(7) Monthly supply costs include all operating supplies such as small tools, rope, cutter teeth, pump wear items, etc. Cost of wear items, such as cutter teeth and certain pump parts will vary greatly with the type material dredged. An upward adjustment should be made when dredging rock or other highly abrasive material, and a downward adjustment made for dredging mud or silt.

(8) Repair costs consist of the monthly average on the basis of the number of operating months per year of the annual labor and material costs for all repairs, drydocking, and minor addition and betterments.

(9) Yard costs pertain to the yard or base supporting the dredging operation and consist of that portion of yard expenses supporting this operation.

(10) Insurance costs consist of premiums paid for marine liability, property, and public liability insurance, and plant insurance.

(11) Lay-up costs consist of all expenses incurred while the dredge and attendant plant are layed up. And is charged as a monthly cost of the assumed number of operating months per year.

(12) The floating, submerged, and shoreline costs should include the fittings, pontoons, winches, etc., normally associated with these lines. The pipeline costs for the project at hand are obtained by multiplying the costs per foot developed for the different types of material (mud, silt, sand, rock) by their respective maximum lengths. For other materials and combinations, causing different rates of pipe wear, the values should be modified by the estimator based on his experience and previous contracts in the same area. Costs for placing and removing of the pipelines are covered under Mobilization and Demobilization.

(13) The entries shown under booster costs will be developed generally in the same manner and subject to the same comments as for the dredging plant.

e. Mobilization & Demobilization. The various costs are itemized on the back of Appendix B and are briefly explained here. All of these costs should consider that only a partial crew and greatly reduced operating costs are applicable.

(1) Mobilize Plant for Transfer includes all attendant plant and pipeline. Costs incurred consist of such items as restoring all machinery to working order and restoring and stocking quarters and mess facilities (if applicable). Preparation for mobilization averages 1/2 to three days.

(2) Transfer All Plant includes all transfer costs including the return of the tug or tugs (if applicable). The distance traveled per day averages 50 to 75 miles. Transfer distance should be based on the second dredge from the job that is expected to bid on the work.

(3) Prepare Plant for Work includes all costs incurred to set up the equipment to start work including assembling and placing the discharge line and boosters (if applicable).

(4) Demobilize Plant for Transfer includes all attendant plant and pipeline and averages 1/2 to two days. Costs incurred include disassembly of all pipeline and preparing it for transport.

(5) Transfer All Plant is similar to the same entry above, however, points of mobilization and demobilization are not necessarily the same.

(6) Prepare Plant for Lay-Up includes all costs to secure machinery and equipment for storage.

(7) Overhead and Bond are based on the same percentage used for the dredging estimate.

(8) Remarks. This space is for remarks to items on Appendix B.

f. Modification Estimates. When an estimate is prepared for a modification to a contract, the average monthly costs used in the Government estimate will need to be adjusted to suit the specific dredge and attendant plant on the job. Equipment ownership costs (including depreciation, interest on investment, insurance, repair, drydocking and layup), shall be determined in accordance with ASPR 15-402.1 and the contract clause entitled "Equipment Ownership Expense Schedule." Care shall be taken that costs are not duplicated since the use of the A.G.C. "Contractors' Equipment Ownership Schedule," 6th Edition, as required by ASPR 15-402.1 includes the above items of cost, (depreciation, interest, taxes, storage, insurance, overhauling, major repairs, painting). An allowance for profit shall also be included in modification estimates in accordance with ER 1180-1-1, paragraph 1-372(e)(iv). Profit shall be determined by the weighted guidelines method as directed by ER 1180-1-1, paragraph 3-808.2.

SAMPLE FORMAT

MONTHLY OPERATION COST FOR BASIC HYDRAULIC DREDGING PLANT H.P. ___

Total H.P. (Dredge Plus Att. Plant)

Payroll (24-hr. operation)

___	Project Manager	$___
___	Superintendent	___
___	Captain	___
___	Chief Engineer	___
___	Civil Engineer	___
___	Office Personnel	___
	Subtotal	
Taxes, ins. & fringes (__%)		___
	Sub-total	___/mo

Date:___________

	Levermen	$ /hr.	$___
___	Watch Engineers	/hr.	___
___	Dredge Mates	/hr.	___
___	Tug Masters	/hr.	___
___	Tug Mates	/hr.	___
___	Equip. Operators	/hr.	___
___	Welders	/hr.	___
___	Oilers	/hr.	___
___	Deckhands	/hr.	___
___	Stewards	/hr.	___
___	Mess Attendants	/hr.	___
___	Gen. Dump Foreman	/hr.	___
___	Dump Foremen	/hr.	___
___	Yard & Shoremen	/hr.	___
___	Total Crew	Sub-total	___

Work ___ hrs. - Pay ___ hrs/wk
Wages (month) (4.34 wks) $_______
Taxes, ins. & fringes (__%) _______
$_______

Labor Total $_______/mo

Ownership & Operation (__mo/yr operation)

Plant	Value Est.	Life	Monthly Cost
Dredge	$___	___ Yrs	$___
___ H.P. Tugs ( )	___	20 Yrs	___
___ Ton Derrick	___	20 Yrs	___
Work Barges ( ) @	___	20 Yrs	___
Fuel-Water Barge	___	20 Yrs	___
Crew Boat	___	6 Yrs	___
Skiff & Outboard ( )	___	4 Yrs	___
Bulldozers ( )	___	4 Yrs	___
Pick-up Trucks ( )	___	4 Yrs	___
Office (Trailer)	___	6 Yrs	___
	$		
Depreciation (Total)			$___
Interest on Investment (%)			___
Fuel Cost			___
Water & Lubricants			___
Supplies			___
Repair & Drydocking			___
Yard Cost			___
Insurance			___
Lay-up (__ months/yr.)			___
Total Monthly Basic Plant & Labor Cost			$___

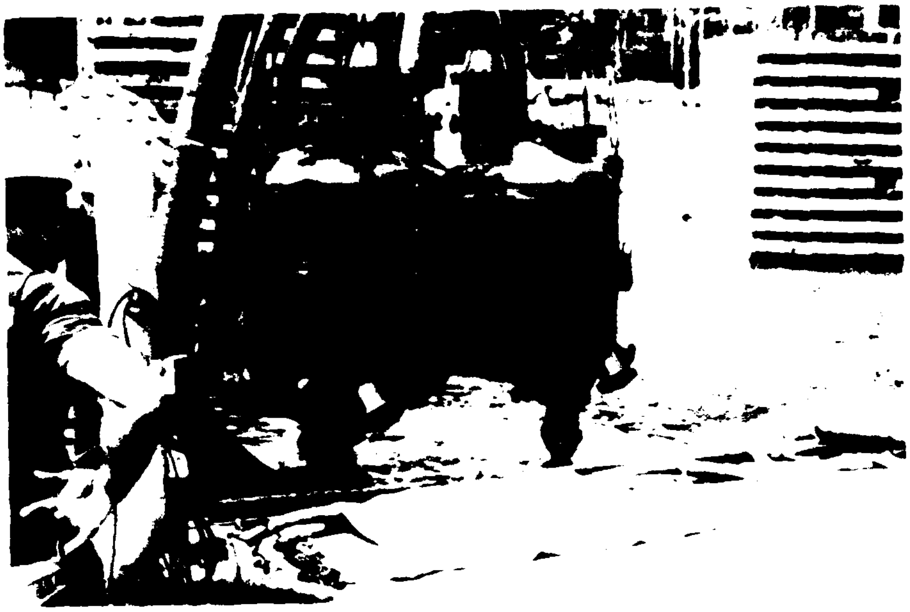
PIPELINE COSTS (Monthly costs/ft.)

Pipeline Costs:	Mud	Sand	Rock
Floating Line	$___	$___	$___
Submerged Line	___	___	___
Shoreline	___	___	___

BOOSTER COSTS (___H.P.) (___YR. LIFE)

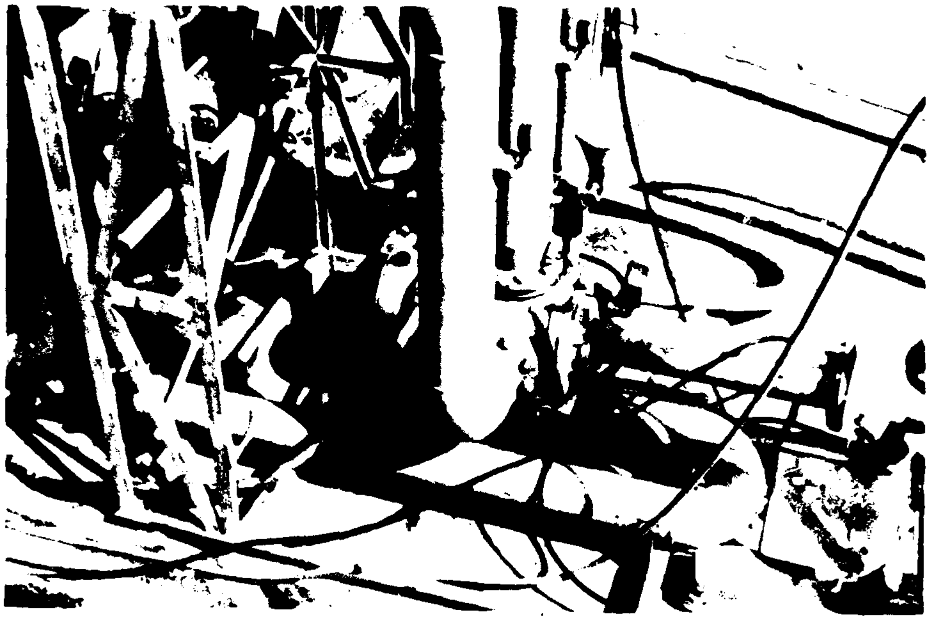
Value $___________		Repairs & Drydock	$___
Depreciation	$___	Yard Cost	___
Interest on Investment (%)	___	Insurance	___
Fuel Cost	___	Lay-up months)	___
Lubricants	___	Payroll	___
Supplies	___	Taxes, Ins. & Fringe	___
		TOTAL COST MONTHLY	___

PNEUMA PUMP FIELD OBSERVATION (CAPE FEAR RIVER)

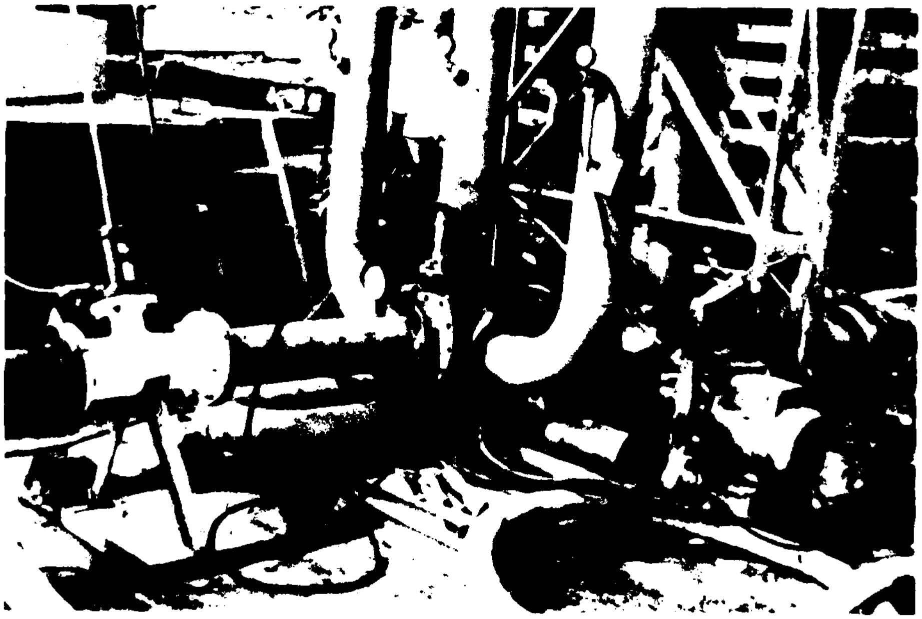


PNEUMA PUMP BODY (THREE CYLINDERS ARRANGED IN A TRIANGLE)

PNEUMA PUMP RIGGING SHOWING DISCHARGE LINE AND AIR SUPPLY LINES

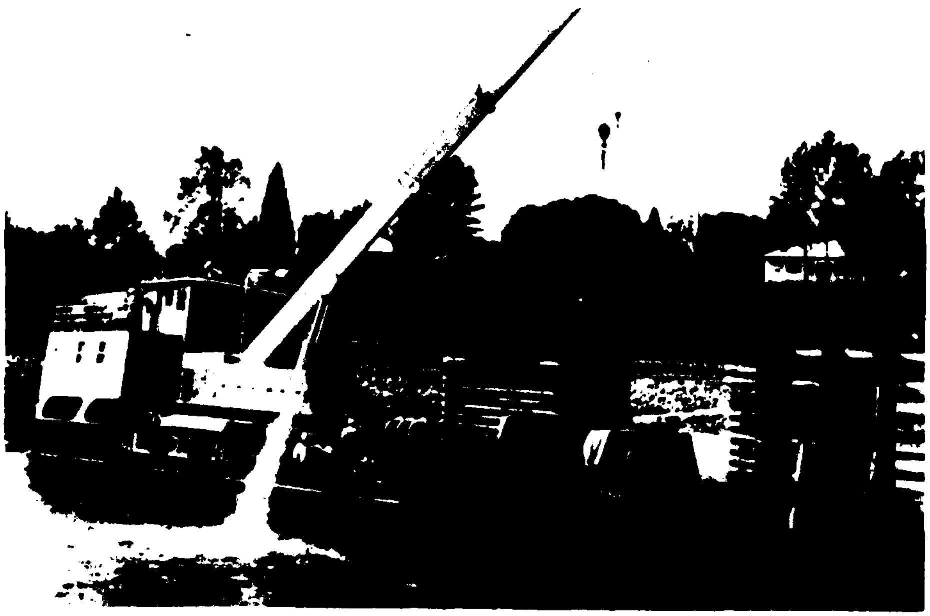


PNEUMA PUMP DISTRIBUTOR. COMPRESSED AIR IS SUPPLIED THROUGH PIPE ON RIGHT AND DISTRIBUTED TO EACH CYLINDER THROUGH VERTICAL PIPES. CURVED PIPE IN FOREGROUND IS EXHAUST LINE.

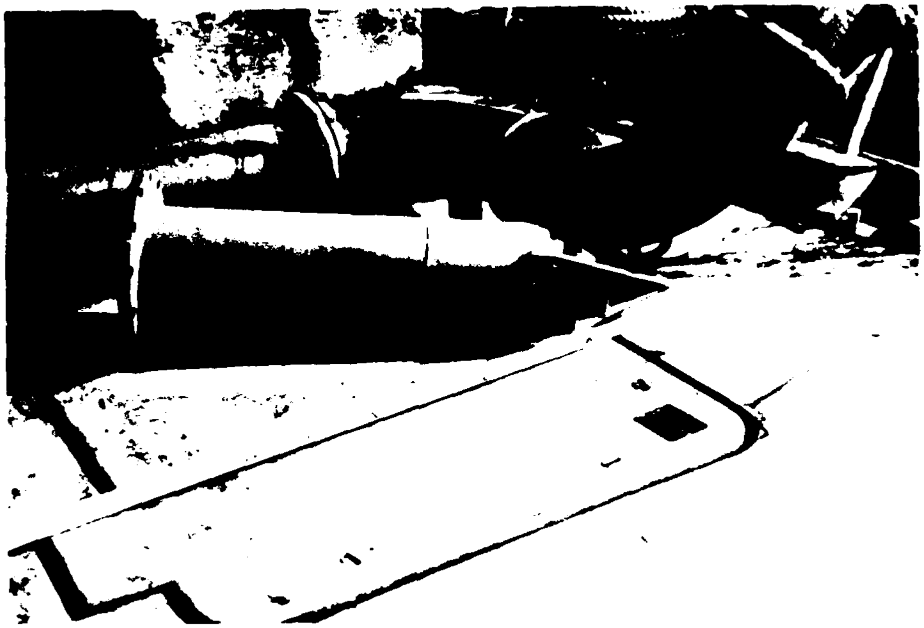


PERSPECTIVE OF PNEUMA PUMP DISTRIBUTOR

RELATIONSHIP OF DISTRIBUTOR TO RIGGING

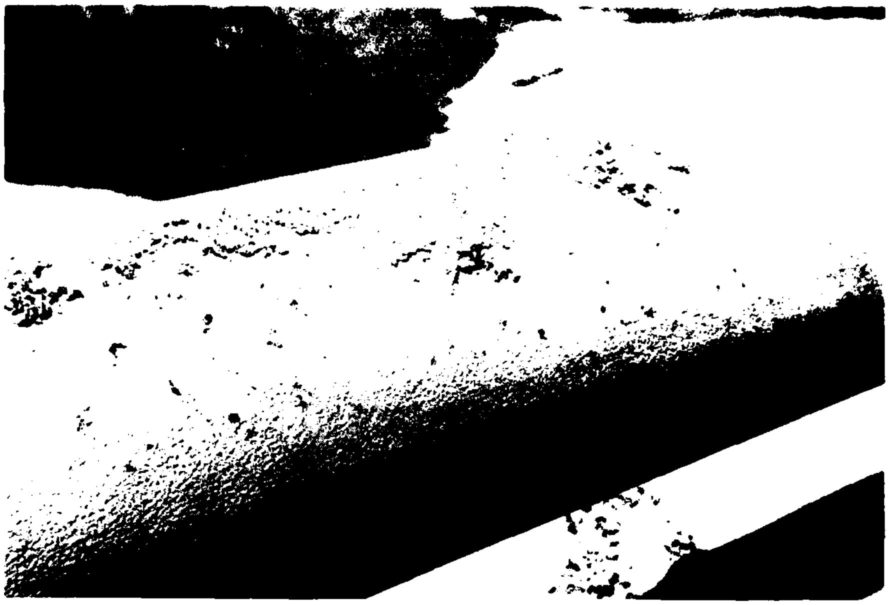


PNEUMA PUMP APPARATUS MOUNTED ON WORKBOAT SNELL. NOTE TWO 1,500-CFM COMPRESSORS, DISCHARGE PIPE, AND DISTRIBUTOR MOUNTED ON DECK.

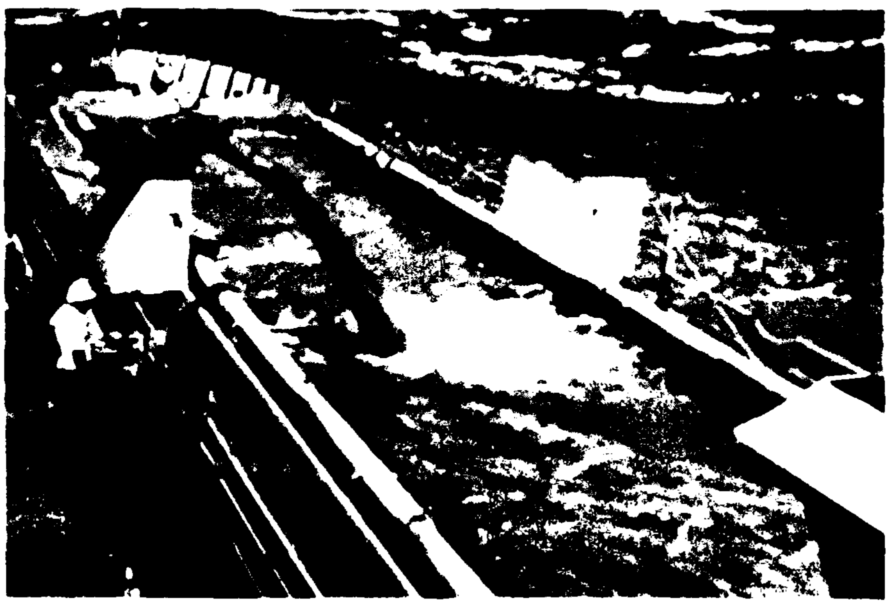


NOZZLES USED ON CAPE FEAR RIVER TEST

TEXTURE AND CONSISTENCY OF MATERIAL BEING DREDGED ON CAPE FEAR RIVER

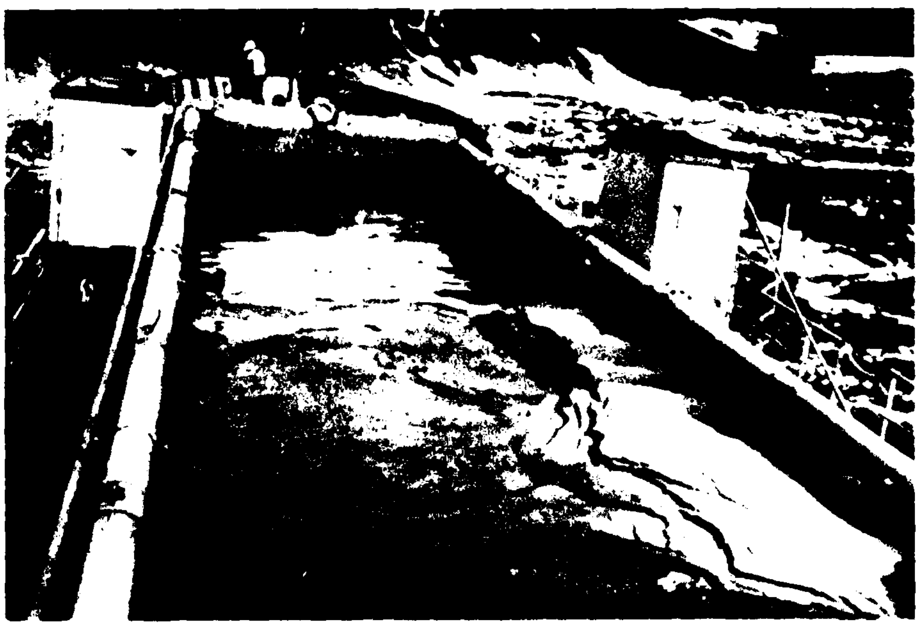


TEXTURE AND CONSISTENCY OF MATERIAL BEING DREDGED
ON CAPE FEAR RIVER



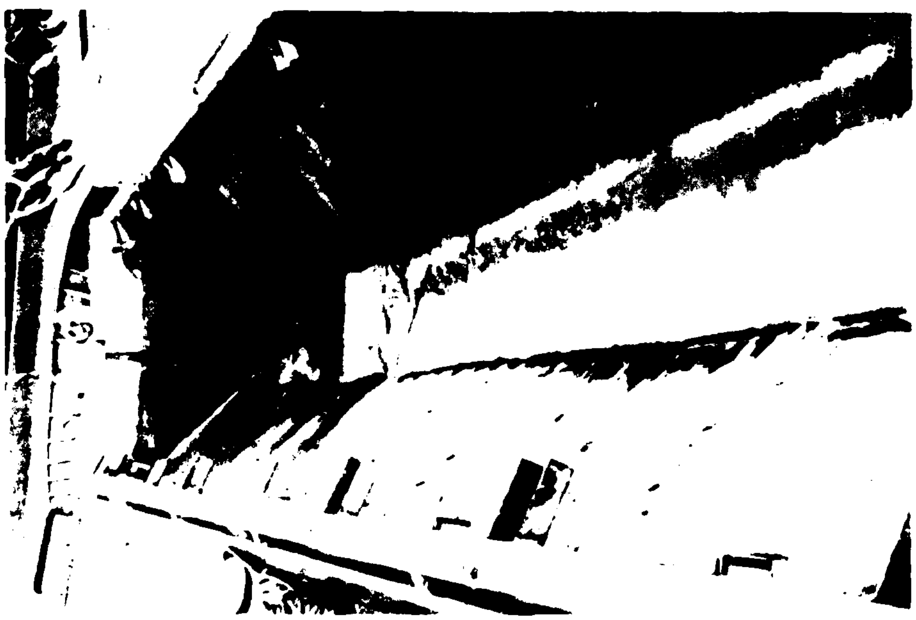
PMEUMA PUMP DISCHARGING INTO CURRITUCK

HOPPER DREDGE CURRITUCK ON THE CAPE FEAR RIVER



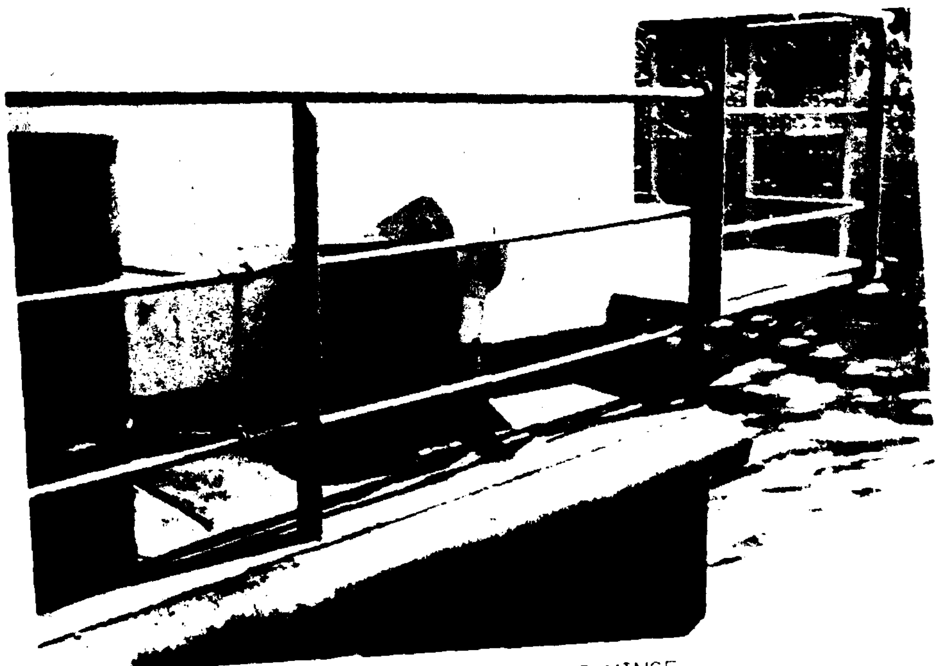
LOADED HOPPER

MIDPOINT OF UNLOADING CYCLE



END OF UNLOADING CYCLE - NOTE HALVES OF HULL
ARE STILL SPLIT.

MAIN HINGE (ONE OF TWO)



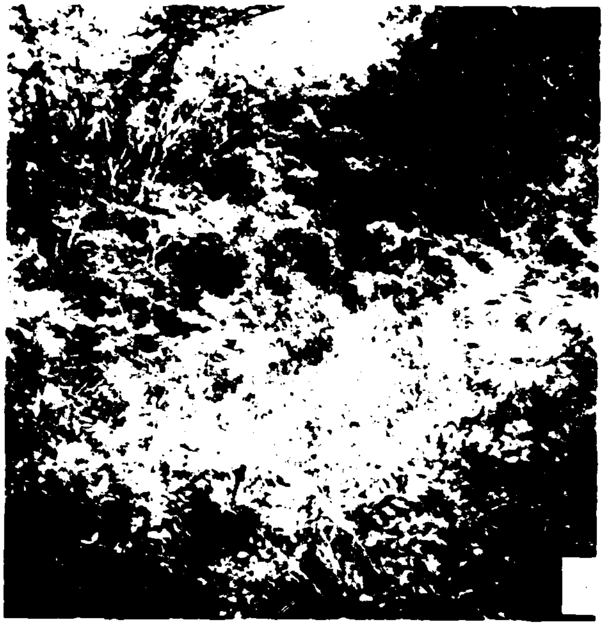
SUPERSTRUCTURE SUPPORT HINGE

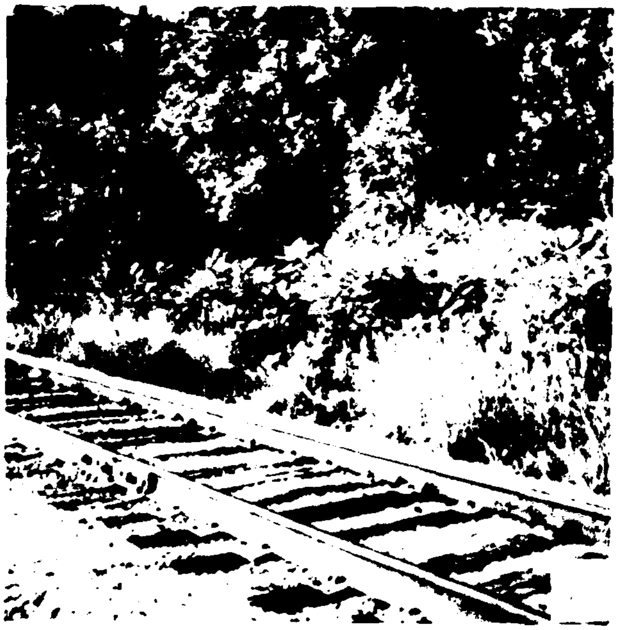
PRESENT DREDGING OPERATION AT READS LANDING

VIEW OF DREDGING OPERATIONS LOOKING TOWARD MINNESOTA AND THE CITY OF READS LANDING (DOWNSTREAM IS TO THE LEFT)

VIEW OF DREDGING OPERATIONS LOOKING TOWARD WISCONSIN AND TREVINO BOTTOMS. NOTE SEDIMENT IN SLOUGHS CLOSEST TO PLACEMENT SITE (DOWNSTREAM TO THE RIGHT)

ROUTE OF PROPOSED READS LANDING SPECIAL PROJECT



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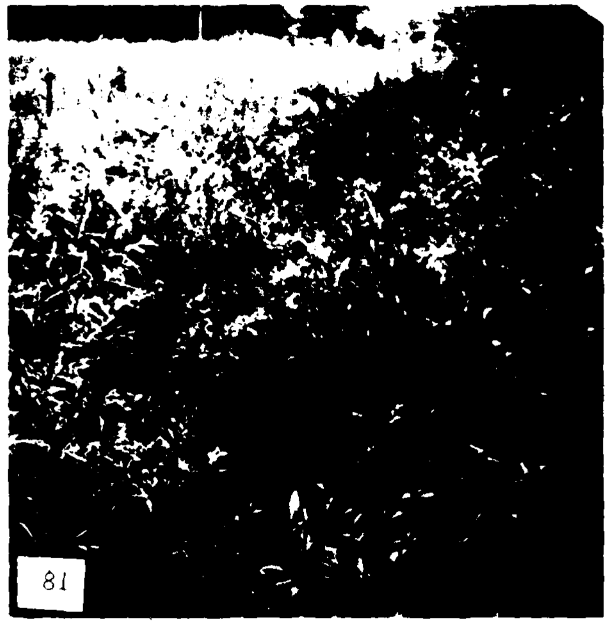
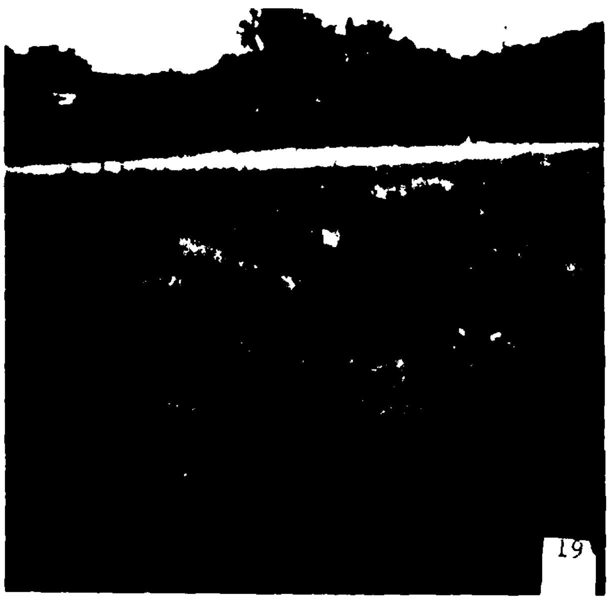
11


17


81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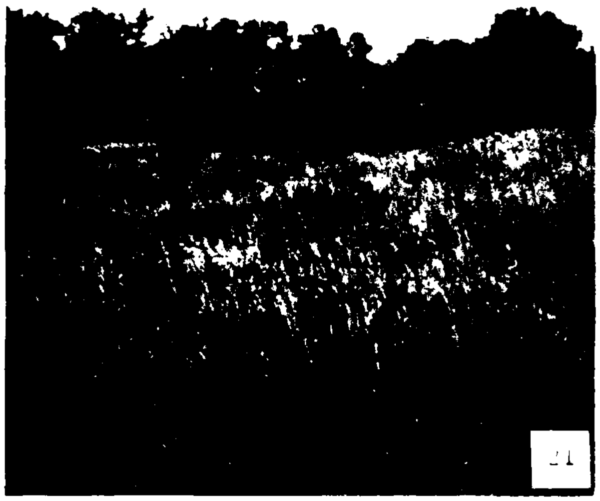

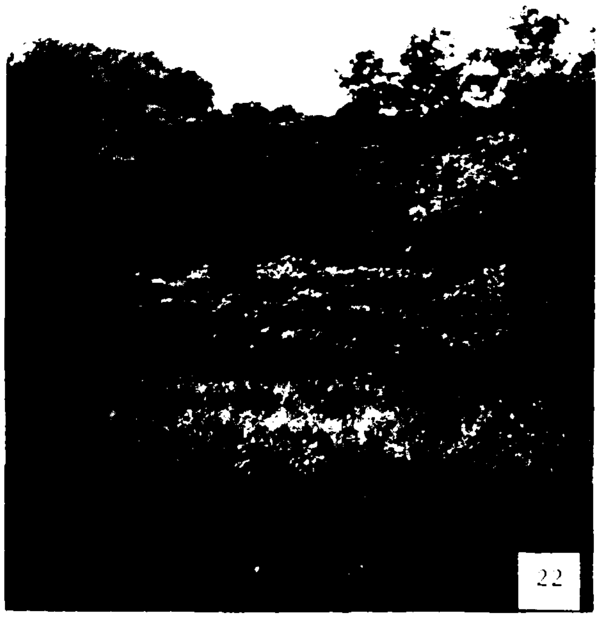

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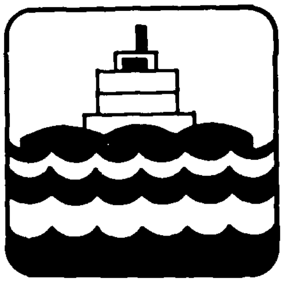


COMMERCIAL TRANSPORTATION

FOREWORD FROM THE GREAT TEAM

This report has been prepared by the Commercial Transportation Work Group of the Great River Environmental Action Team (GREAT I). The conclusions and recommendations contained in this report reflect the work performed by this work group only, within its specific area of expertise. Recommendations from this report will be considered in relation to other objectives for overall resource management and may be included in the final GREAT I report as considered appropriate by the GREAT I Team.

River transportation is a safe, economical and energy efficient system. It benefits every man, woman and child in the GREAT I area.

" The area in which China has the most to learn from America is water transport, especially the Mississippi and Great Lakes systems."

- Peking People's Daily, 2 December 1978

TABLE OF CONTENTS

TABLE OF CONTENTS (CONT)

TABLES

FIGURES

ATTACHMENTS

COMMERCIAL TRANSPORTATION WORK GROUP

CONCLUSIONS AND RECOMMENDATIONS

The Commercial Transportation Work Group is part of GREAT (the Great River Environmental Action Team) which was formed as a result of the Water Resources Development Act of 1976. The work group was active from 1976 through 1979. Its objective was to determine present and future problems and needs of commercial river transportation and identify alternatives to solve these problems and satisfy these needs. The area of concern was the Mississippi River from the head of navigation at Minneapolis, Minnesota, to Guttenberg, Iowa; the lower 24.5 miles of the St. Croix River; the lower 14.7 miles of the Minnesota River; and the lower 1.4 miles of the Black River.

This appendix presents the work group's opinions and recommendations. It is being forwarded to GREAT I for review and will be included in the final report. Where recommendations differ from those adopted by GREAT, the work group recommendation should be considered a minority report.

As a result of its efforts, the work group reached the following conclusions and recommendations (not in any order of priority):

CONCLUSIONS

1. Commercial river transportation is a vital link in the total GREAT I transportation network.

2. The Corps of Engineers has recently made significant changes in its channel maintenance dredging and disposal practices. Preliminary indications are that some environmental improvements have been made as a result of these changes. However, various adverse effects have also resulted. Of particular interest to commercial navigation

is that changes to navigation channel dredging and disposal practices have been implemented without first analyzing their consequences.

3. Riverine disposal may present the least cost and most environmentally desirable method of dredged material disposal.

4. Waterway commerce for the Upper Mississippi River has exceeded high growth predictions from Cairo, Illinois, to St. Paul, Minnesota, every year since 1964 and exceeded predictions by 9 1/2 million tons in 1974 (River Transportation in Iowa, Iowa Department of Transportation, May 1978).

5. Commercial transportation is a function of economic conditions and government policies operating in the free enterprise system and is far below what the river can support.

6. Traffic congestion at locks and dams 2 and 3 could become a serious problem during peak use periods.

7. Restrictive bridges impede safe efficient water navigation and must be rebuilt to provide adequate horizontal and vertical clearance. Truman-Hobbs legislation is not flexible enough to meet current demands and public needs.

8. Bridge delays and other channel closures can be extremely costly. Those costs are ultimately passed on to consumers.

9. The myriad of Federal, State and local government agency involvement and/or regulations affecting water transportation, terminals, and support facilities has resulted in duplication, contradiction, confusion, and unnecessary delays. These problems are particularly evident in obtaining fleeting, terminal, and dredging permits.

10. Regulatory constraints on the development of new or expanded commercial shore, terminal, and support facilities have adversely affected the economy.

11. Work group traffic studies have indicated that:

a. By 1985, total downbound barge shipments in the GREAT I area will increase substantially over 1975 levels; the primary increase will be in agriculture products.

b. Existing problems such as fleeting shortages and locking wait times will intensify.

c. No new problems caused by increased traffic are foreseen.

12. User charges on water transportation will increase shipping costs for GREAT I area residents. Farmers would be most affected because farm commodities account for more than half of the barge traffic. In 1985, on the basis of current predictions, the fuel tax will result in an increased cost of over $4.8 million ($0.08 per gallon).

13. GREAT I studies have not identified all of the users and beneficiaries or uses and benefits that result from a navigation project in the GREAT I area.

14. Available fleeting areas are insufficient to meet present and future industry needs.

15. Identifying all potential fleeting areas is necessary in selecting the most desirable site to meet industry needs and environmental concerns. The Upper Mississippi River Basin Commission Level B Study Report and Environmental Impact Statement concerning commercial river navigation in the St. Paul/Minneapolis area support the needs of navigation in that area.

16. Predesignated closing and opening shipping dates would adversely affect the economy.

17. The suitability models of the Geographic Information System, as currently designed, are not appropriate for identifying areas suitable for barge fleeting or terminals.

18. Reflective coatings on barges would have no practical beneficial impact for the recreational boater.

19. Barge tie-off requirements are very difficult to standardize because of the many different terminal and fleeting area conditions. The scope of this problem in the GREAT I area is insignificant and does not demand further study. Additionally, sufficient incentives already exist for industry to provide suitable tie-offs.

RECOMMENDATIONS

1. The channel should continue to be maintained, preserved, and expanded to meet current and future barge needs of vessels with 9-foot drafts. Specific recommendations for implementation are contained in the work group guidelines for channel maintenance dredging and disposal.

2. GREAT should acknowledge that the guidelines and standards for channel maintenance as historically practiced by the Corps of Engineers have provided an adequate navigation channel for 9-foot draft vessels. Before any changes or deviations from these practices are implemented, the following potential impacts must be considered: risk of grounding, transit time, fuel consumption, cargo capacity, and dredging and disposal costs.

3. Congress should define the Mississippi River 9-foot navigation project as "including allowances required for advance maintenance

dredging, dredging tolerances, squat and trim for the class of vessel for which the project was designed, wave action, shoaling rates, and other overdepth allowances necessary to afford safe navigation for vessels with a draft of 9 feet."

4. Riverine disposal should be considered as a viable alternative in formulating dredged material disposal plans.

5. Any GREAT recommendation referring to channel maintenance should include the historical costs and the additional costs resulting from that recommendation.

6. The Corps should maintain fiscal records and publish an annual report comparing the costs for historical and current channel maintenance.

7. The Corps should recommend steps to Congress to alleviate projected capacity limitations at locks and dams 2 and 3 caused by demand increases. Mid-America Ports Study, Recreation Lock Study and GREAT I Recreation Work Group concerns should be considered.

8. Obstructive bridges should be rebuilt to provide adequate horizontal and vertical clearances. The Truman-Hobbs Act should:

a. Continue to be used in rebuilding bridges on the basis of navigation needs.

b. Be amended to include replacement or repair of bridge protection systems.

c. Be amended to include benefits to land as well as marine interests. Because public money is being spent, the total public benefit should be considered in benefit cost ratios.

9. Operating regulations for drawbridges must be vigorously enforced by the U.S. Coast Guard. To accomplish this, the acts of 18 August 1864 and 3 March 1899, the Bridge Act of 1906, and the General Act of 1946 should be amended to provide for civil penalties in certain circumstances and for other purposes as recommended by the U.S. Coast Guard.

10. A comprehensive study should be made to identify Federal, State, and local regulatory activities applicable to river transportation. The study should identify areas in which Federal laws and agencies must supersede State and local regulatory activities and develop recommendations to eliminate the contradiction and intrusion by State and local government into the Federal domain of interstate commerce.

11. The cost and benefit to the public of constraints on the development of commercial facilities should be evaluated.

12. Beneficiary/user data should be developed and used by appropriate agencies in managing water resources and developing cost-sharing programs.

13. The commercial transportation industry should participate in identifying potential fleeting areas for meeting present shortages and future development.

14. Predesignated opening and closing navigation dates should not be established.

15. The Geographic Information System should be refined, expanded, or modified and include all recommendations contained in the section on suitability models.

16. State and Federal agencies concerned with boating safety should intensify efforts to educate recreational boaters on rules of the

road and lighting requirements applicable to commercial and recreational vessels.

INTRODUCTION

GREAT I BACKGROUND

In 1973, the State of Wisconsin initiated a lawsuit against the Corps of Engineers over various dredging and disposal actions practiced by the St. Paul District to maintain the authorized 9-foot navigation channel on the Upper Mississippi River. As a result, the North Central Division Engineer and the North Central Regional Director of the U.S. Fish and Wildlife Service announced in September 1974 that they planned to establish a partnership team within the North Central Division area. The purpose of the team would be to work out a long-range management strategy for the multipurpose use of the river. Previously, the Upper Mississippi River Basin Commission had established a Dredged Spoil Disposal Practices Committee to lay the groundwork for similar, related efforts. These initiatives were combined and became known as GREAT. From 1974 to 1976, most of GREAT's activities were focused on the Minnesota-Wisconsin portions of the Upper Mississippi River. Finally, in section 117 of the Water Resources Development Act of 1976, Congress formally authorized the investigation and study of the development of a river system management plan for the entire Upper Mississippi River. The section reads:

> "The Secretary of the Army, acting through the Chief of Engineers, is authorized to investigate and study, in co-operation with interested States and Federal agencies, through the Upper Mississippi River Basin Commission, the Development of a river system management plan in the format of the 'Great River Study' for the Mississippi River from the mouth of the Ohio River to the head of navigation at Minneapolis, incorporating total river resource requirements including, but not limited to, navigation, the

effects of increased barge traffic, fish and wildlife, recreation, watershed management, and water quality at an estimated cost of $9,100,000."

To accomplish the study, the Corps, together with the other study participants, divided the study into three geographic areas:

1. GREAT I. - The Great I study centers around the Corps St. Paul District and covers that reach of the Mississippi River from the head of navigation at Minneapolis to Guttenberg, the lower 24.5 miles of the St. Croix River, the lower 14.7 miles of the Minnesota River, and the lower 1.4 miles of the Black River.

2. GREAT II. - The GREAT II study centers around the Corps Rock Island District and concentrates on the Mississippi River and its tributaries from Guttenberg to Saverton, Missouri.

3. GREAT III. - The GREAT III study centers around the Corps St. Louis District and covers the Mississippi River from Saverton to the confluence with the Ohio River.

GREAT I study participants included, but were not limited to, the Corps of Engineers; Fish and Wildlife Service; Environmental Protection Agency; Soil Conservation Service; Department of Transportation (Coast Guard); agencies of the States of Iowa, Minnesota, and Wisconsin; and various interest groups.

COMMERCIAL TRANSPORTATION WORK GROUP BACKGROUND

GREAT I established work groups to address various areas of concern. The Commercial Transportation Work Group's objective was to determine present and future problems and needs of commercial river transportation and alternatives to meet these needs. For planning purposes, the work group undertook to:

1. Define the existing legal and institutional framework for commercial river transportation.

2. Define present and potential demand for commercial river transportation.

3. Identify the capacity of the river for commercial transportation.

4. Determine problems and needs of commercial river transportation including barge fleeting areas, terminals, and other support facilities.

5. Delineate and evaluate commercial river transportation planning activities.

6. Draft the commercial transportation appendix.

The work group established the following procedures:

1. Meetings were held on an "as needed" basis which resulted in a meeting every 1 to 2 months.

2. Meetings were open to any and all interested parties.

3. An extensive mailing list was maintained. Any party desiring to be placed on that list was provided advance notification of all meetings, copies of meeting minutes, and descriptions of the issues being considered.

4. Decisions and policies were made by the consensus of those in attendance at the meetings.

5. Strict, formal rules and procedures such as formal voting membership designations and quorum and/or voting procedures were not found to be necessary and were not established.

6. All parties on the mailing list were encouraged to provide comments on the work group's efforts even if they could not attend the meetings.

7. The work group's chairman, with the advice of the work group, handled general administrative duties including scheduling and arranging for meetings and preparing minutes, reports, and general correspondence. The chairman has been a representative from the Coast Guard.

8. All work group business, including conclusions and recommendations in the final report, were approved by general agreement.

The size of the work group (that is, its mailing list) varied throughout the study effort; however, it usually had over 45 members representing a broad range of interests including but not limited to the barge and towing industry; terminal operators; railroads; private citizens; municipalities; Departments of Transportation of Iowa, Minnesota, and Wisconsin; Coast Guard; Corps of Engineers; Fish and Wildlife Service; and Maritime Administration. Attendance at meetings was generally between 7 and 15 people.

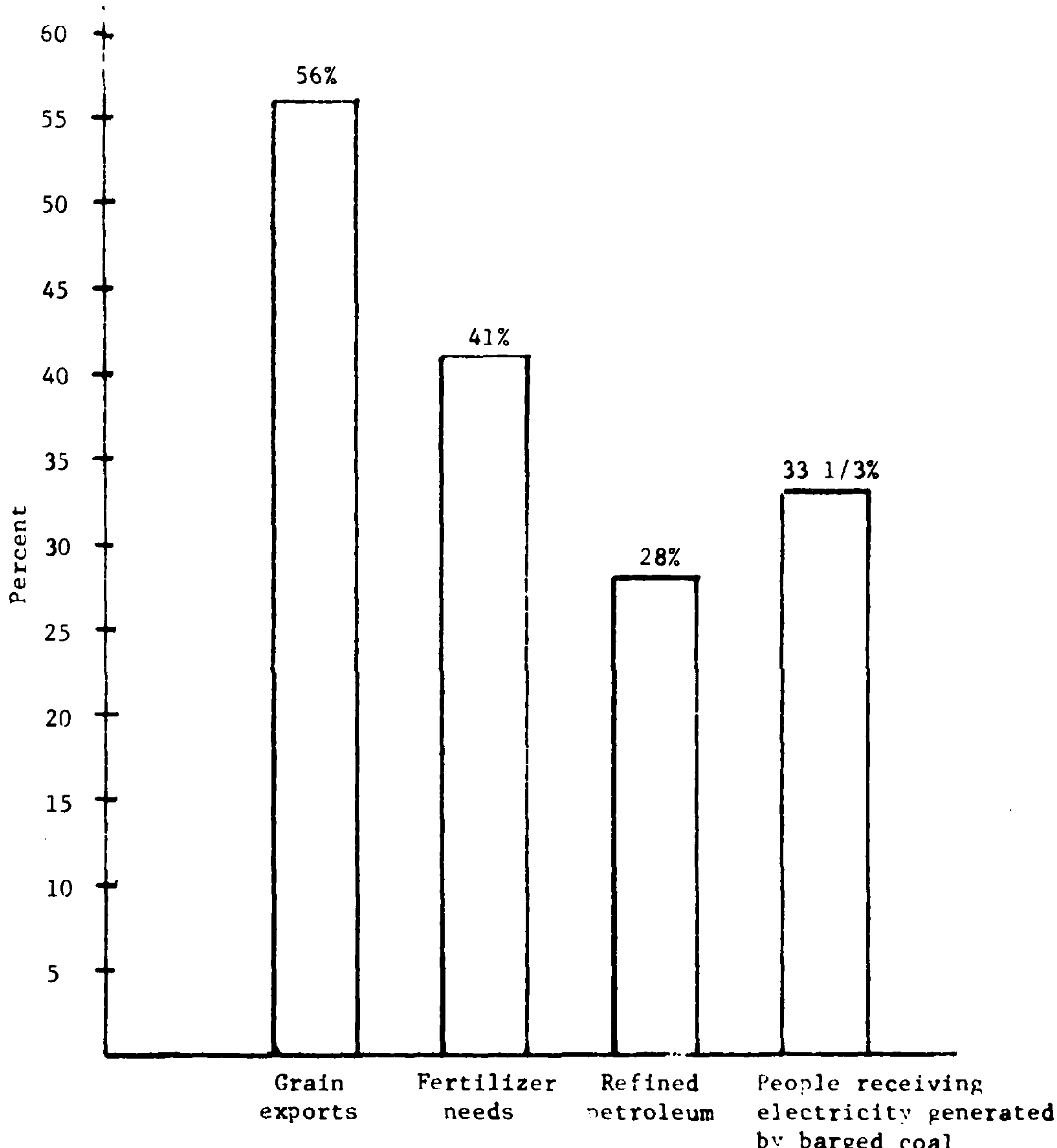
As indicated by the above procedures, significant efforts were made to obtain public participation. The primary nongovernmental inputs came from representatives of the barge and towing industry and the railroads. Additionally, a representative of the GREAT I Public Participation and Information Work Group attended most work group meetings.

COMMERCIAL TRANSPORTATION IN THE GREAT I AREA

Commercial transportation is composed of several "modes" - waterway, rail, highway, and air. In considering commercial transportation as it relates to the GREAT I mandate of developing a river system management plan, it is readily apparent that the waterway mode is of major interest.

Waterway

The commercial river transportation system in the GREAT I area consists primarily of a 9-foot navigation channel, 13 locks, towboats, barges, fleeting areas, and terminals. By its nature, the system provides services of vital importance to the economy of the area. A 1975 study by the Upper Mississippi Waterway Association concluded that the river system handles 56 percent of the area's grain exports, 41 percent of the area's fertilizer, and 28 percent of its refined petroleum products (see the following figure). Additionally, about one of every three people in the Upper Mississippi River basin is served by electricity generated from barged coal.

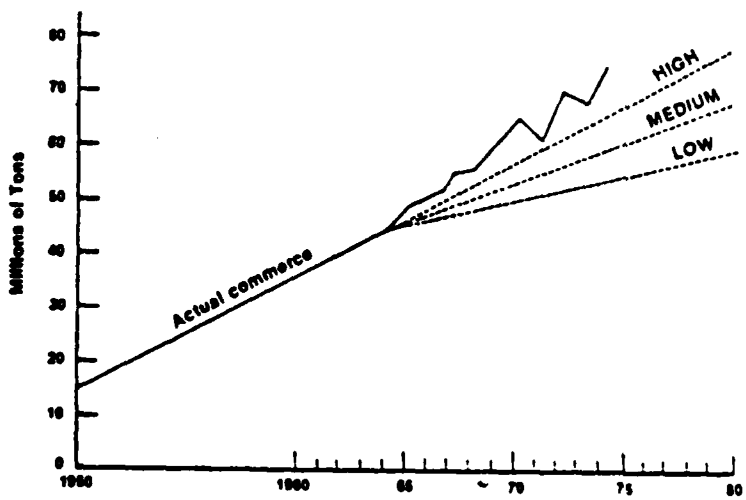


Percentage of area commodities handled by river transportation

Source: Upper Mississippi Waterway Association study, 1975

An additional study completed by the work group has provided baseline data on movements of bulk commodities in the GREAT I area. This study also compared water shipments to total shipments and the transportation rates for the different transportation modes.

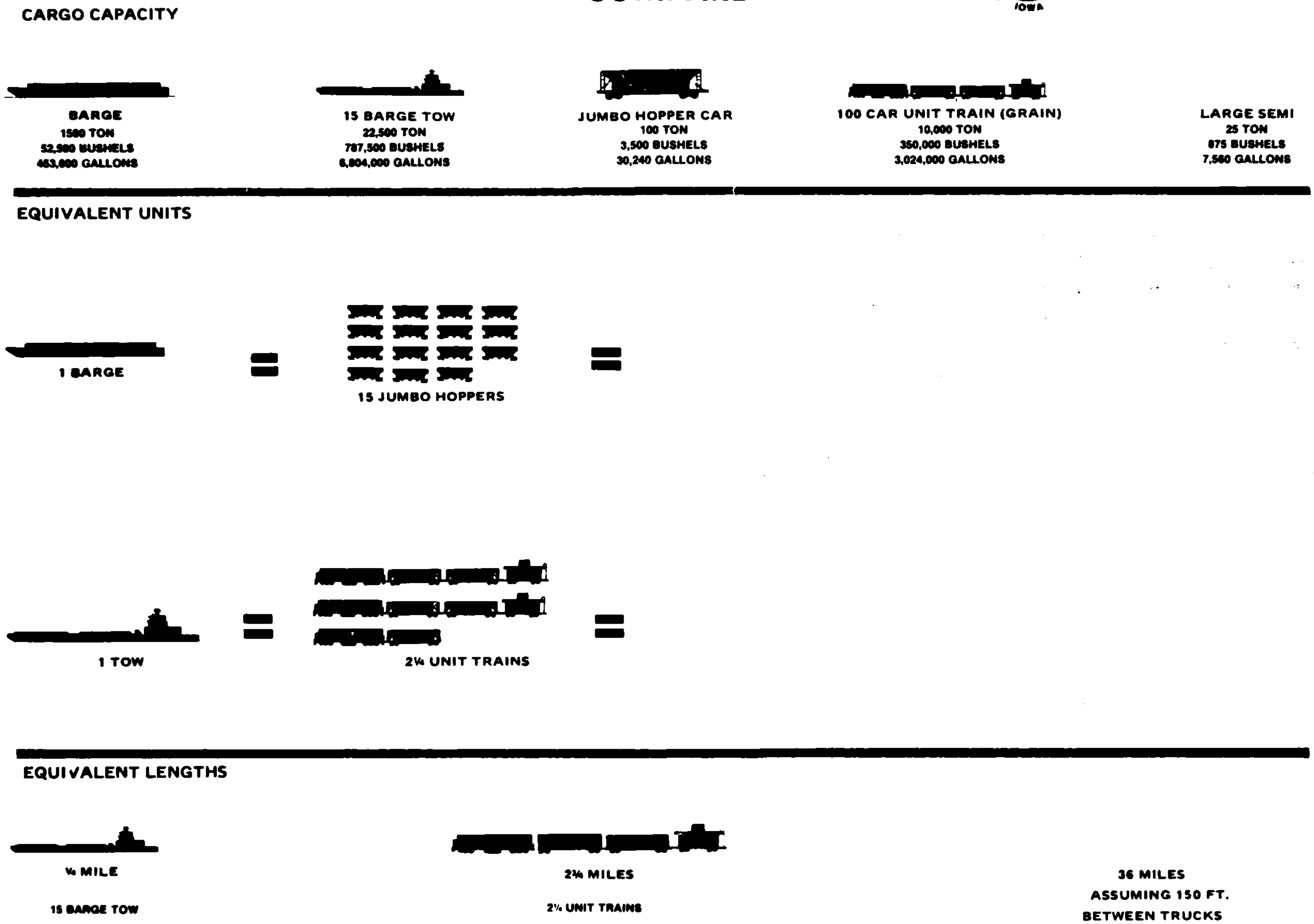
Waterway traffic is unique in the high volumes of commodities that can be handled by just one barge (see the figure on page 14). Also, extremely large pieces of equipment, such as giant turbines and rockets, are best handled by barge. Rail or truck roadbeds and fixed bridges and power lines do not facilitate land transportation of large equipment. Waterway transportation is also unique in that it is the safest and results in the lowest shipping cost. Over the years, it has developed to meet the needs of commerce. The following figure shows the rate of growth from 1950 to 1964 and compares actual growth with 1964 predictions by the Upper Mississippi River Basin Commission. As can be seen, actual growth has exceeded projections for every year from 1964 through 1975.



Source: Upper Mississippi River Basin Commission 1975 Decision Oriented Information Base

Actual and projected commerce on the Upper Mississippi River

COMPARE



Prepared by:
Planning and Research Division

Rail and Highway

The rail and highway systems in the area are made up of various rail and road beds, bridges, and terminals. They are of vital importance to the transportation system and the economy of the area. The whole transportation system should be considered so that the natural advantages of each mode can be fully used. However, although the work group recognizes the importance and contribution of the other transportation modes, its studies concentrated on waterway transportation as the primary element of a river management plan.

STUDY ACTIVITIES

The work group's six tasks are listed on page 9. During the study, it became evident that time and funding resources were inadequate for completion of all tasks. Also, the work group became involved in miscellaneous other efforts which, while valuable, further detracted from its ability to fully complete the original tasks. This section of the report describes the study activities which were addressed.

DEMAND FOR COMMERCIAL RIVER TRANSPORTATION

One of the original work group tasks was to define the present and potential demand for commercial river transportation. The work group addressed this task via a contract with the University of Minnesota. The final report for the study is included as a separate document.

Projections to the year 1985 were made for 20 commodities which are shipped in large amounts by barge. The commodities selected accounted for over 97 percent of barged shipments to and from the Twin Cities area in 1976. All commodities with a 1976 total exceeding 50,000 short tons were included.

Commodity projections were made from a base year of 1975 for seven different cases as shown in the following table.

Commodity projections

Case	Description
1985 base-line case	Assumed most likely case.
1A	1985 base-line case modified for a 50-percent increase in raw farm product shipments.
1B	1985 base-line case modified for a 50-percent decrease in raw farm product shipments.
2	1985 base-line case modified for four additional 800-megawatt electric generating units using western coal.
3	1985 base-line case modified for four additional 800-megawatt electric generating units using southern coal.
4	1985 base-line case modified for a 50-percent increase in raw farm products and four additional 800-megawatt electric generating units using western coal (cases 1A and 2).
5	1985 base-line case modified for a 50-percent increase in raw farm products and 4 additional electric generating units using southern coal (cases 1A and 3).

On the basis of commodity projections, barge requirements, lock requirements, and lock uses were estimated. Also, the effect of user charges on the total commercial barging bill for 1975 was analyzed. Selected results of these projections are presented in the following paragraphs and tables.

Base-line projections for 1985 for St. Paul District ports are based primarily on a previous analysis of Twin Cities area ports conducted by the University of Minnesota Department of Agriculture and Applied Economics (Historical and Projected Volumes of Twin Cities Waterborne Commerce 1963-1985, Title V Report 21). The projected case volumes are considered the most likely and would result in an increase in total barge shipments of 59 percent over 1975 levels; the increase would be primarily in raw farm products. An analysis of the base line indicates no major new problems although existing problems such as fleeting area pressures and locking queue time would intensify as a result of increased traffic. Although the requirements for fleeting would not increase proportionately with traffic under most circumstances, the disproportionate increase in downbound farm product traffic under the base-line case and cases 1A, 2, 4, and 5 would undoubtedly require additional terminal storage areas. Case 1A would appear to present problems similar to those of the base line, but of a greater magnitude. On the other hand, the traffic in case 1B would remain at about the same level as in 1975.

The effect of increased coal movements by barge would depend on whether the coal is western coal moving south or southern coal coming north. Major movements of western coal would require a greatly increased number of lockages and additional barges as well as fleeting areas. On the other hand, upbound coal movements should be generally complementary with downbound grain movements if cleaning facilities are adequate. The work group position is that all alternatives in locating new facilities will have to be considered within the context of economic, environmental, traffic, and social conditions existing at the time of decision.

Lock congestion at locks and dam 2 might become a serious problem in the near future. Under case 4, the time required for projected lockages in August exceeded hours in the month. It is recommended that commercial recreational lockage requirements of locks and dams 2 and 3 be studied in detail (for example, a simulation to determine times and magnitude of excessive lockage demand).

Historically, Congress has assisted all transportation and other non-transportation programs to encourage their development. The overriding criterion in allocating public funds is the public interest to be served by the program. The present administration favors a payback for navigation project costs. A user charge in the form of a fuel tax was enacted as a condition for approval of locks and dam 26 replacement. Railroad interests strongly favor user charges for waterborne commerce. Considerable debate is still centered on the equitable application of Government subsidies. Waterborne commerce interests contend that such programs as railroad retirement fund subsidies, low interest loans, and railroad right-of-way land grants are subsidies greater than the Government investment in the inland waterway system. They also believe waterborne commerce is already paying its way because about 9 percent of the U.S. Customs revenues generated by waterborne commerce would cover the annual operation, maintenance, and construction costs of the entire inland waterway system. User fees would increase shipping costs for residents of the GREAT I area. Farmers would be affected the most because farm commodities and production goods account for more than one-half the barge ton-miles in GREAT I. Impacts will also be felt in the energy sector because a major portion of the coal used in generating electricity and crude oil and petroleum products are moved by barge. Under existing (1975) traffic patterns, revenues from the proposed fuel tax would amount to $1 million at the $0.04 per gallon level and $2.5 million at a $0.10 per gallon level for all commodities shipped into or out of the St. Paul District.

Total shipments by pool (tons)

Pool	Year								
		1985							
	1975	Base line	Case 1A	Case 1B	Case 2	Case 3	Case 4	Case 5
Minneapolis	2,518,363	1,704,887	1,909,650	1,500,125	4,558,887	1,704,887	4,763,650	1,909,650
Minnesota River	2,403,085	6,141,951	9,085,244	3,198,661	6,141,951	6,141,951	9,085,244	9,085,244
St. Paul	2,183,173	4,455,965	5,406,023	3,505,910	13,017,965	4,455,965	13,968,023	5,406,023
Pool 2	2,554,480	2,485,003	2,485,003	2,485,003	2,485,003	2,485,003	2,485,003	2,485,003
Pool 3	5,478	5,089	5,089	5,089	5,089	5,089	5,089	5,089
Pool 4	354,325	646,251	879,489	393,015	636,251	636,251	879,489	879,489
Pool 5	0	0	0	0	0	0	0	0
Pool 6	352,662	938,861	1,400,316	477,406	938,861	938,861	1,400,316	1,400,316
Pool 8	82,056	237,763	119,458	237,763	237,763	237,763	356,069	356,069
Pool 9	0	0	0	0	0	0	0	0
Pool 10	588,472	936,406	1,404,610	468,204	936,406	936,406	1,404,610	1,404,610
Total	11,042,094	17,552,176	22,694,882	12,271,176	28,958,176	17,542,176	34,347,493	22,931,493

Reference: R.A. Hill and J.E. Fruin, Projections of 1985 Bulk Commodity Barge Traffic on St. Paul District Waterways, 4 August 1978 (review draft).

Total receipts by pool (tons)

Pool	Year							
		1985						
	1975	Base line	Case 1A	Case 1B	Case 2	Case 3	Case 4	Case 5
Minneapolis	639,621	986,785	986,785	986,785	986,785	986,785	986,785	986,785
Minnesota River	1,313,057	1,391,955	1,391,955	1,391,955	1,391,955	1,391,995	1,391,995	1,391,995
St. Paul	2,696,485	2,920,293	2,920,293	2,920,293	2,920,293	2,920,293	2,920,293	2,920,293
Pool 2	647,132	690,266	690,266	690,266	690,266	690,293	690,293	690,293
Pool 3	1,697,499	1,407,845	1,407,845	1,407,845	1,407,845	1,407,845	1,407,845	1,407,845
Pool 4	59,581	122,601	122,601	122,601	122,601	122,601	122,601	122,601
Pool 5	634,127	504,316	504,316	504,316	6,212,316	4,784,316	6,212,316	4,784,316
Pool 6	226,298	321,409	321,409	321,409	321,409	321,409	321,409	321,409
Pool 8	258,863	337,589	337,589	337,589	337,589	337,589	337,589	337,589
Pool 9	1,339,253	1,787,207	1,787,207	1,178,207	1,178,207	1,178,207	1,178,207	1,178,207
Pool 10	22,602	65,860	65,860	65,860	65,860	65,860	65,860	65,860
Total	9,534,518	10,536,126	10,536,126	10,536,126	15,632,126	14,207,193	15,635,193	14,207,193

Reference: R.A. Hill and J.E. Fruin, Projections of 1985 Bulk Commodity Barge Traffic on St. Paul District Waterways, 4 August 1978 (review draft).

Total trip/lockage requirements

Pool	Direction	Year 1975	1985 Base line	1985 Case 1A	1985 Case 1B	1985 Case 2	1985 Case 3	1985 Case 4	1985 Case 5
Locks and dam 1	Upriver (loaded)	881	600	600	600	1,584	600	1,584	600
(2 barges)	(empty)	203	246	316	175	246	246	316	316
	Downriver (loaded)	204	246	316	175	246	246	316	316
	(empty)	880	600	600	600	1,584	600	1,584	600
Total lockages		2,168	1,692	1,832	1,550	3,660	1,692	3,800	1,832
Minnesota River	Upriver (loaded)	350	344	344	344	344	344	344	344
(4 barges)	(empty)	415	1,061	1,570	554	1,061	1,061	1,570	1,570
	Downriver (loaded)	416	1,061	1,570	554	1,061	1,061	1,570	1,570
	(empty)	349	344	344	344	344	344	344	344
Total trips		1,530	2,810	3,828	1,796	2,810	2,810	3,828	3,828
Locks and dam 2	Upriver (loaded)	258	335	335	335	860	335	860	335
(15 dry cargo, 8	(empty)	159	345	534	157	345	345	534	534
tank barges)	Downriver (loaded)	242	451	640	263	451	451	640	640
	(empty)	175	229	229	229	754	229	754	229
Total lockages		834	1,360	1,738	984	2,410	1,360	2,788	1,738
Locks and dam 3	Upriver (loaded)	264	280	280	280	805	280	805	280
(15 dry cargo, 8	(empty)	106	322	511	134	322	322	511	511
tank barges)	Downriver (loaded)	242	451	640	263	451	451	640	640
	(empty)	128	151	151	151	676	151	676	151
Total lockages		740	1,204	1,582	828	2,254	1,204	2,632	1,582
Locks and dam 10	Upriver (loaded)	328	264	375	375	638	571	638	571
(15 dry cargo, 8	(empty)	92	332	598	103	350	154	598	402
tank barges)	Downriver (loaded)	300	556	822	327	574	574	822	822
	(empty)	120	40	151	151	414	151	414	151
Total lockages		840	1,192	1,946	956	1,976	1,450	2,472	1,946

Reference: R.A. Hill and J.E. Fruin, Projections of 1985 Bulk Commodity Barge Traffic on St. Paul District Waterways, 4 August 1978 (review draft).

Time spent in lockages for the month of August (hours)

		Year							
			1985						
Pool	Type	1977 (1)	Base line	Case 1A	Case 1B	Case 2	Case 3	Case 4	Case 5
Locks and dam 1	Recreational	107.7	161.6	161.6	161.6	161.6	161.6	161.6	161.6
	Commercial	191.8	132.0	141.8	120.9	284.9	132.0	294.8	141.8
	Total	299.5	293.6	303.4	282.5	446.5	293.6	456.4	303.4
Lock use (2)		40.3	39.5	40.8	38.0	60.0	39.5	61.3	40.8
Locks and dam 2	Recreational	153.9	230.9	230.9	230.9	230.9	230.9	230.9	230.9
	Commercial	227.7	257.2	342.4	172.0	498.6	257.2	583.8	342.4
	Total	381.6	488.1	573.3	402.9	729.5	488.1	814.7	573.3
Lock use (2)		51.3	65.6	77.1	54.2	98.1	65.6	109.5	77.1
Locks and dam 3	Recreational	166.6	249.9	249.9	249.9	249.9	249.9	249.9	249.9
	Commercial	170.9	192.0	260.8	123.2	381.2	192.0	447.1	260.8
	Total	337.5	441.9	510.7	373.1	631.1	441.9	697.0	510.7
Lock use (2)		45.4	59.4	68.6	50.1	84.8	59.4	93.7	68.6
Locks and dam 10	Recreational	156.8	235.2	235.2	235.2	235.2	235.2	235.2	235.2
	Commercial	200.8	239.8	334.4	145.3	340.5	239.8	432.0	334.4
	Total	357.6	475.0	569.6	380.5	575.7	475.0	667.2	569.6
Lock use (2)		48.1	63.8	76.6	51.1	77.4	63.8	89.7	76.6

(1) Data from U.S. Army Corps of Engineers Performance Monitoring System.
(2) Lock use represents the percentage of time spent in the lockage out of 744 total hours in August.

Reference: R.A. Hill and J.E. Fruin, Projections of 1985 Bulk Commodity Barge Traffic on St. Paul District Waterways, 4 August 1978 (review draft).

Increased cost of barge transportation (based on actual 1975 tonnage)

Item	Cost: $0.04 per gallon	$0.06 per gallon	$0.08 per gallon	$0.10 per gallon
Shipments to out of District ports	$1,006,302.43	$1,509,453.65	$2,012,604.86	$2,515,756.08
Receipts from out of District ports	560,430.44	840,645.66	1,120,860.88	1,401,076.10
Intra-District movements	20,148.78	30,223.17	40,297.56	50,371.95
Total	1,586,881.65	2,380,322.48	3,173,763.30	3,967,204.13

Reference: R.A. Hill and J.E. Fruin, Projections of 1985 Bulk Commodity Barge Traffic on St. Paul District Waterways, 4 August 1978 (review draft).

IMPORTANCE OF COMMERCIAL RIVER TRANSPORTATION

A follow-up contract with the University of Minnesota was approved in December 1978. Its purpose was to identify and document movements of bulk commodities on the river, determine the magnitude of river traffic in relation to total movement of those commodities and determine the rates for the different transportation modes.

Two reports - one covering grain and one covering fertilizers - are attached. Reports on coal, petroleum and petroleum products, and other commodities are being prepared. A summary of this material is included as attachment 6.

The major findings of this study are that:

1. An average of 2.3 million tons of corn per year was shipped by barge from the Twin Cities from 1971 to 1977. This amount is 28 percent of the corn sold off Minnesota and South Dakota farms and 89 percent of the corn shipped from Minneapolis - St. Paul. Barges also carried 67 percent of the wheat and over 90 percent of the soybeans shipped from the Twin Cities to the Gulf ports for export. Cost is one reason for the dominanace of water transport of grain. Contract barge rates for the 1979 shipping season from the Twin Cities to the Gulf were between $7 and $7.50 per ton. Rail rates for 10-car shipments were over $25 per ton. The difference in transportation costs amounts to more than $0.50 per bushel.

2. The amount of phosphate chemical fertilizer received in St. Paul District terminals in 1975 was more than 95 percent of the amount used in Minnesota (some of the fertilizer was used in neighboring States). An amount of mixed fertilizers equal to 39 percent of Minnesota use was received at St. Paul District ports. Transportation rates for barge-rail delivery of dry bulk fertilizers from Florida are $10 to $12 less per ton than all-rail rates.

3. Barges dominate the movement of anhydrous ammonia near waterways. However, pipeline transportation costs are cheaper than barge-truck costs if the distance is more than 100 miles inland. Consequently in 1975, a quantity of nitrogen fertilizer equal to 25 percent of Minnesota use was received by barge at a savings up to $10 per ton.

4. Significant amounts of crude petroleum, gasoline, and petroleum products are received by barge in the Twin Cities area. Pipelines are generally the cheapest mode for moving petroleum; however, there is a shortage of pipeline capacity from the south and a reduction in availability of Canadian crude oil for area refineries. Water transportation has been very important in minimizing energy shortages in the Upper Midwest in recent years.

5. At least five major area power plants depend almost completely on barge transportation for coal because they have no rail facilities. For those plants using Illinois or Kentucky coal, barge transportation costs are about one-half of rail costs.

The following table shows some of the major commodity movements in the area.

Major commodity movements and cost of movements to and from St. Paul ports

Commodity	Comparison area	Total comparison area shipments or consumption (tons)	Barge movement (tons)	Percent comparison area	Estimate of cost per ton by water in 1979	1979 cost Per ton by alternative mode (1)
1976 Corn	Corn shipped through Minneapolis-St. Paul	2,319,000	2,132,000	91.9	Twin Cities to Gulf $6-7	Twin Cities to Gulf, 10-car export rate $25.30
1976 Wheat	Wheat, handled by Minneapolis-St. Paul area elevators	2,643,000	2,035,000	77.0	Twin Cities to Gulf $6-7	Twin Cities to Gulf, 10-car export rate $25.30
1976 Soybeans	Soybeans shipped through Minneapolis-St. Paul	682,000	665,000	97.6	Twin Cities to Gulf $6-7	Twin Cities to Gulf, 10-car export rate $25.30
1975 Nitrogen fertilizer Phosphatic fertilizer Mixed fertilizer	Minnesota	1,577,000	533,600	33.8	Anhydrous ammonia(2) New Orleans to St. Paul $18.00 St. Paul to Rochester by truck(3) 10.80 Total 28.80	Rail from Medicine Hat, Alberta, to Winnebago, MN $34.32
					Phosphate fertilizers Tampa to Winona by vessel and barge $13.00 Winona to Austin by rail 3.51 Total 16.51	Rail from Bartow, FL, to Austin, MN $25.72

					Tampa to St. Paul by vessel and barge $13.00 St. Paul to Moorhead by rail 7.89 Total 20.89	Rail from Bartow, FL, to Moorhead, MN $32.06
1976 Eastern and midwestern coal	Eastern and midwestern coal consumed in Minnesota received by other than lake vessel	2,650,000	1,760,000	63.0	St. Louis area to Twin Cities Mine to barge by rail (4) $3.00 Transfer to barge(4) 1.00 Barge 2.50 Total 6.50	Rail from mine at multiple car rate of $0.017 per ton-mile (4) $9.82
1976 Western coal	Power plants on Mississippi River in St. Paul District without rail access	2,295,119	2,295,119	100.0	Comparisons are not applicable because primary movement is by rail. Rail-barge is used because facilities at plant are unable to receive large quantities of coal by rail.	
1978 (preliminary) Crude petroleum and petroleum products from Midwest and Gulf locations	Minnesota	16,058,768	1,591,000	9.9	Gulf to Twin City area $7.12-9.49 (5)	Gulf to Twin City area by pipeline $6.98
1978 (preliminary) Petroleum products refined in Twin Cities	Twin City area	Not available	1,131,000	Not available	Pine Bend to Minneapolis	Pine Bend to Minneapolis by truck (20 miles) $2.22(5) for gasoline $2.55(5) other product

(1) Interstate rail rates are Ex Parte 357 Level; Minnesota intrastate rail rates are Ex Parte 343 level.
(2) Unit tow.
(3) January 1979 Minnesota intrastate rates.
(4) Estimate.
(5) 1975 traffic rates.

ECONOMICS OF WATER TRANSPORTATION

This task addressed:

1. The economic consequences of inadequate channel maintenance.

2. Barge draft and channel dimensions.

3. Commercial vessel groundings.

Inadequate Channel Maintenance

Channel Maintenance. - The towing industry and principal users of waterborne commerce on the Upper Mississippi River are concerned that channel maintenance, as a result of an agreement between the Minnesota Pollution Control Agency and the Corps of Engineers in 1978, will provide a less reliable channel. Groundings and channel blockages may increase and emergency dredging procedures may not be implemented quickly enough to minimize the economic impact on the towing industry, the users of the river, and the agrarian economy of the Upper Midwest. The economic consequences of blockages and the impact that uncertainty and concern over potential blockages have had on operations and capital investment are substantial.

Actual blockages. - While it is extremely difficult to calculate the financial costs of groundings and channel blockages, it is possible to identify the broad areas of economic impact. Because a substantial percentage of the downbound movement on the Upper Mississippi River is grain, primarily corn and soybeans, it is necessary to have a basic understanding of grain merchandising to measure the impact. Grain sales generally carry delivery dates. The seller is under obligation to deliver at a specified time to a terminal or a vessel at Gulf ports. If the Upper Mississippi River is not available to the seller to effect such a delivery, or if commodities already in transit are tied up by channel blockage so that delivery cannot be made by the specified date, the seller must divert other shipments of the same commodity in transit downbound beyond the blockage, go into the market and procure commodities in other areas and duplicate the shipments, or assume the cost of vessel demurrage at the port. The consequences are reduced prices at the farm, general confusion in the intermodal transportation network, and a dampening of the Upper Midwest agrarian economy. More grain stays on the farm or in country elevators. Since grain is sold domestically and internationally on the basis of specified delivery dates, failure to complete a contract within a specified time may result in reduction in the total movement of grain from the Upper Midwest during a season. The grain merchandiser may have reduced profits or even a net loss resulting from higher prices paid in another market to duplicate the shipment, losses on commodities tied up in transit when eventually sold to other buyers, and vessel demurrage. Other costs such as fixed costs of equipment and salaries of personnel continue for the towing company while its equipment is idled by the channel blockage. Based on a 3,200- to 4,200-horsepower unit, it has been estimated that the cost for a line tow incapacitated by a channel blockage is about $4,800 a day. The only cost reduction would be in less fuel consumed.

During 1978, a channel blockage at Reads Landing closed the navigation channel. The channel was totally blocked for 5 days and partially blocked for 4 more days. The blockage resulted in a delay of 58 towboat-days and 467 barge-days. This does not account for tows that knowing of the blockage never departed from berths nor the subsequent delays at locks, terminals, and fleeting areas downriver. The economic loss based only on towboat-days is $278,400. The towing company may incur additional monetary losses from channel blockage by its inability to meet its contractual agreements to furnish equipment to users. In short, the whole schedule is set back for the navigation season. The impact to the grain merchandiser and the towing industry can probably be measured in monetary terms; however, the impact on the agribusiness community of the Upper Midwest may be substantial loss of markets for agricultural commodities. While the downbound grain movement has substantial impact on the agribusiness community, the upbound movement of fertilizer may be nearly as important to agriculture.

Uncertainty and concern over potential blockages. - The navigation season on the Upper Mississippi River is already limited by climatic conditions. The river's availability during the period which has come to be known as the normal navigation season is critical. It is obvious that equipment utilization, costs per ton-mile, and a wide range of operational costs are substantially better for the towing company on the Illinois and Ohio Rivers and lower reaches of the Mississippi River. While there has always been an imbalance of tonnage on the Upper Mississippi River, the imbalance has heightened as a result of a shift to low-sulphur coal moving in trainload movements from Montana to electric generating plants serving the Upper Midwest. The loss of movement of Illinois and Kentucky coal upbound on the Upper Mississippi River has resulted in more one-way traffic for equipment. While, as in all business enterprises, many factors determine what product lines will be developed and where capital investments will be made, uncertainty over getting authorization for adequate channel maintenance, the potential of groundings or actual blockages, and concern over the regulatory process will result in a reduced commitment by the towing industry of its resources to the Upper Mississippi River or increased rates. It may be a leveling off or no-growth stand, and it could be a "cutback".

Is there an inconsistency between allegations for greater use of the Upper Mississippi River and the potential leveling off trend in the industry? The potential for greater use of the river for agricultural products of the Upper Midwest is even brighter in terms of new international markets. The need for greater reliance on riverborne commerce to meet the growing and critical energy needs of the Upper Midwest is obvious. Given a supportive governmental climate for development, the free enterprise system will develop the market.

Barge Draft and Channel Dimensions

This section supports the work group's concern over the effects of changing channel dimensions on cargo capacity and operating efficiency. The economic effect of minor draft changes can be significant. Energy consumption and efficiency are becoming more important. Therefore, it is important to emphasize the reduced efficiency and increased fuel consumption associated with the different channel configurations shown below. When draft is reduced by 1 foot, it takes seven tows to accomplish what was done by six tows. As a result, fuel consumption, shipping costs, and other detrimental impacts on the environment and navigation system would increase substantially. The following table illustrates the economic importance of barge draft.

The economic importance of barge draft

Assume	Single barge capacity = 1,500 tons or 52,500 bushels Draft empty = 1 foot, 10 inches Draft full = 9 feet Cost to ship grain = $7/ton (St. Paul-New Orleans One barge tow (15 barges) carries 22,500 tons or 787,500 bushels

Market price(1)	15-barge cargo value
Corn-$2.20/bushel	$1,732,500
Wheat-$3.50/bushel	2,756,250
Beans-$6.78/bushel	5,339,250

The cost for manning towboat, travel time, fuel costs, speed, etc., remain the same for barges with 8- or 9-foot drafts. Therefore, total transportation costs would remain nearly the same.

Calculate	$7/ton x 1,500-ton capcity = $10,500 shipping cost per barge $10,500/barge x 15-barge tow - $157,500 shipping cost Difference between full and empty draft = 9 feet - 1 foot, 10 inches = 86 inches 1,500 tons÷86 inches = 17.44 tons or 610 bushels per inch of draft per barge.
Result	15-barge tow 1 inch draft reduction = $0.0825 increased cost per ton 1 foot draft reduction = $0.0825 x 12 = $0.99 increased cost per ton $0.99 x 22,500 = $22,275 increased cost per trip

For every six barge tows, a complete new barge trip is needed to transport the same amount of commodity with a 1-foot reduction in draft.
Fuel use is substantially increased because of additional trips required.
Additional trips may cause increased costs for delays at locks, terminals, etc.

(1) As of 26 October 1978.

A Corps sponsored investigation into the effects of channel width and depth on barges was conducted at the University of Michigan Department of Naval Architecture and Marine Engineering in 1960. The data accumulated do not always indicate a direct proportional increase or decrease as the channel width and depth vary. Such irregularities are the result of:

1. The actual level the channel water decreases during the passage of the tow.

2. Changes in trim as a result of change in relative position of wave crests and troughs.

3. Changes in relative pressures between bottom of tow and channel bottom which cause tow to squat (sink bodily).

4. The relative influence of the wave of translation on the resistance of the tow.

The study found the following effects on a 3-barge wide, 2-barge long tow drawing 8.5 feet at 1,000 tow rope horsepower.

Effects of channel width and depth on speed of tows (1)

Channel width (feet)	Channel depths		
	11 feet	13 feet	18 feet
125	3.7 knots	4.10 knots	5.02 knots
225	4.55 knots	5.30 knots	6.38 knots
300	4.95 knots	5.67 knots	6.64 knots

(1) Speed that can be maintained in given channel by 3-barge wide, 2-barge long tow, 8.5-foot draft, 1,000 tow rope horsepower.

It can be readily seen that a given channel width or depth has a direct effect on vessel performance. If the effect of a 50-foot channel width reduction resulted in a 0.4-knot speed loss it would be considered inconsequential by some. The cumulative effect, if applied uniformly to the 1,700-mile trip from St. Paul to New Orleans, would result in over 5 hours being added to the vessel's trip. Multiplied by the number of barge trips, the effect could be substantial. The same is true of channel depth.

Vessel performance relates not only to increased shipping cost, but to energy consumption, effects on the environment, maneuverability, and safety. For example, to travel 4.5 knots in a 125-foot channel reouires almost double the horsepower (1,900 horsepower vs. 1,000 horsepower) for the same speed in a 225-foot channel.

Channel dimensions also affect vessel safety. The Dredging Requirements Work Group addressed this subject through a study performed by the Delft Hydraulics Laboratory. The study determined that the directional stability of vessels is reduced when the water depth is less than 1.5 times their draft.

Commercial Vessel Groundings

GREAT asked the work group to compile accident data indicating the frequency of groundings. Its concern was to determine the effects of reduced channel maintenance since the inception of GREAT. The work group was reluctant to undertake this analysis because of the many variables involved. Additional cautions were given in that not all groundings are reported to the Coast Guard, of those reported only the most serious groundings are officially investigated, and the direct or indirect cause of the groundings may not be accurately identified on the accident forms. For example, the official cause of a grounding may be an error in judgment on the part of the vessel operator. The indirect cause may be channel maintenance or channel alignment that results in inadequate navigation factors for vessel operation. Another cause could be inadequate channel depth that reduces the vessels' maneuvering capabilities.

Data used in developing the graphs were obtained from the Coast Guard and Corps of Engineers. The following figure indicates water levels and groundings for the Upper Mississippi River. 1977 was a low-water year during which the water level was over 1 1/2 feet above normal pool for only 13 days, as compared to 167 days in 1978. 1978 appears to be a more typical year and presents a greater range of river conditions on which to develop a grounding frequency rate. In the figures on pages 35 and 36, the water discharge curve has been inverted for ease in correlating water levels to grounding rates. It is interesting to note that 50 percent of all the reported groundings in GREAT I for 1978 occurred between river miles 705.5 - 706.5 and 816.1 - 817.1

AD-A126 969 GREAT I: A STUDY OF THE UPPER MISSISSIPPI RIVER VOLUME 3 MATERIAL AND EQUIPMENT NEEDS COMMERCIAL TRANSPORTATION(U) GREAT RIVER ENVIRONMENTAL ACTION TEAM SEP 80

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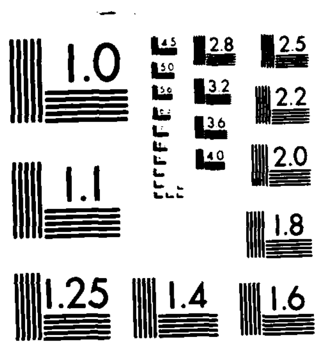
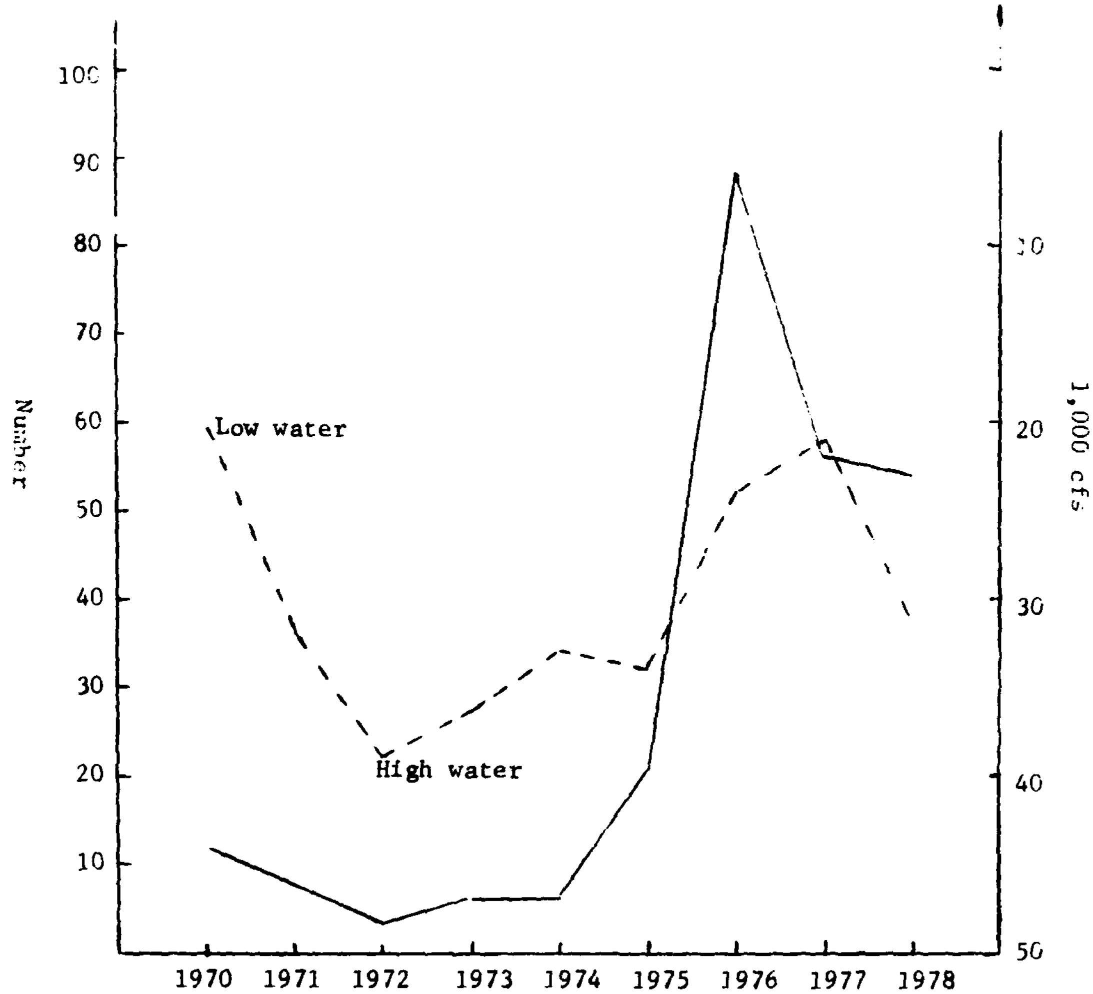


MICROCOPY RESOLUTION TEST CHART

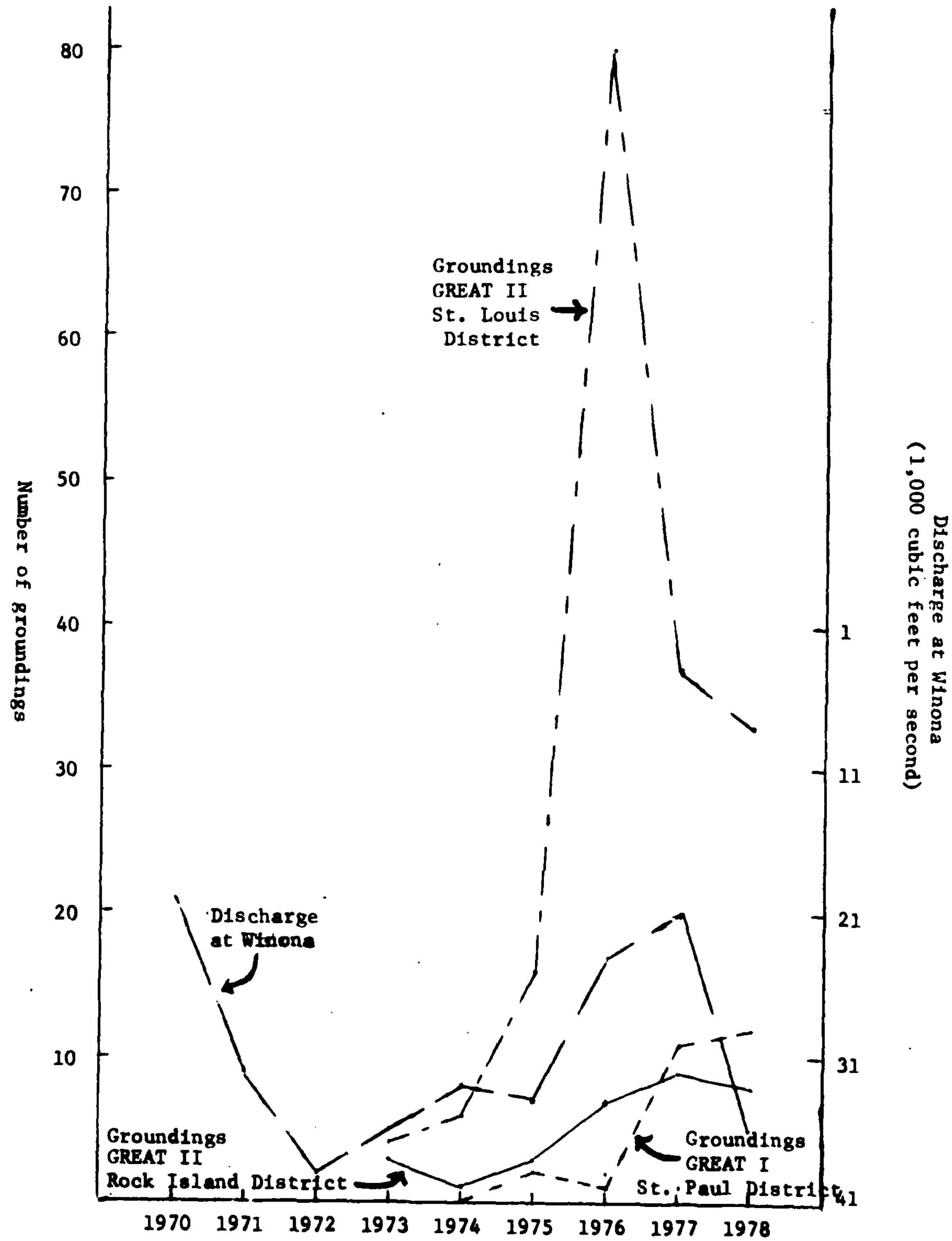
NATIONAL BUREAU OF STANDARDS-1963-A



——— Number of groundings, use scale at left

– – – – Average yearly discharge rates at Winona, Minnesota, use scale at right

Groundings in the Upper Mississippi River



Groundings in the Upper Mississippi River by District

Specific conclusions based on the previous figure, such as "Groundings increase in GREAT I because of reduced channel maintenance procedures in 1978 while grounding rates were decreasing in GREATS II and III," could not be supported if subjected to a statistical analysis. This is the result of an insufficient number of data being used to develop the graph and unexplained deviations from the trend which occurred in 1976 for GREAT I. Some general trends have been identified and conclusions of the work group are:

1. Water levels, both high and low, directly affect the rate of vessel groundings. Open river areas are affected to a much greater degree than pooled portions.

2. Grounding is most frequent during periods of low water defined as below normal pool of 645.50 at Winona to one-half foot above normal pool. During low water, channel maintenance appears to be a more critical factor than at higher stages.

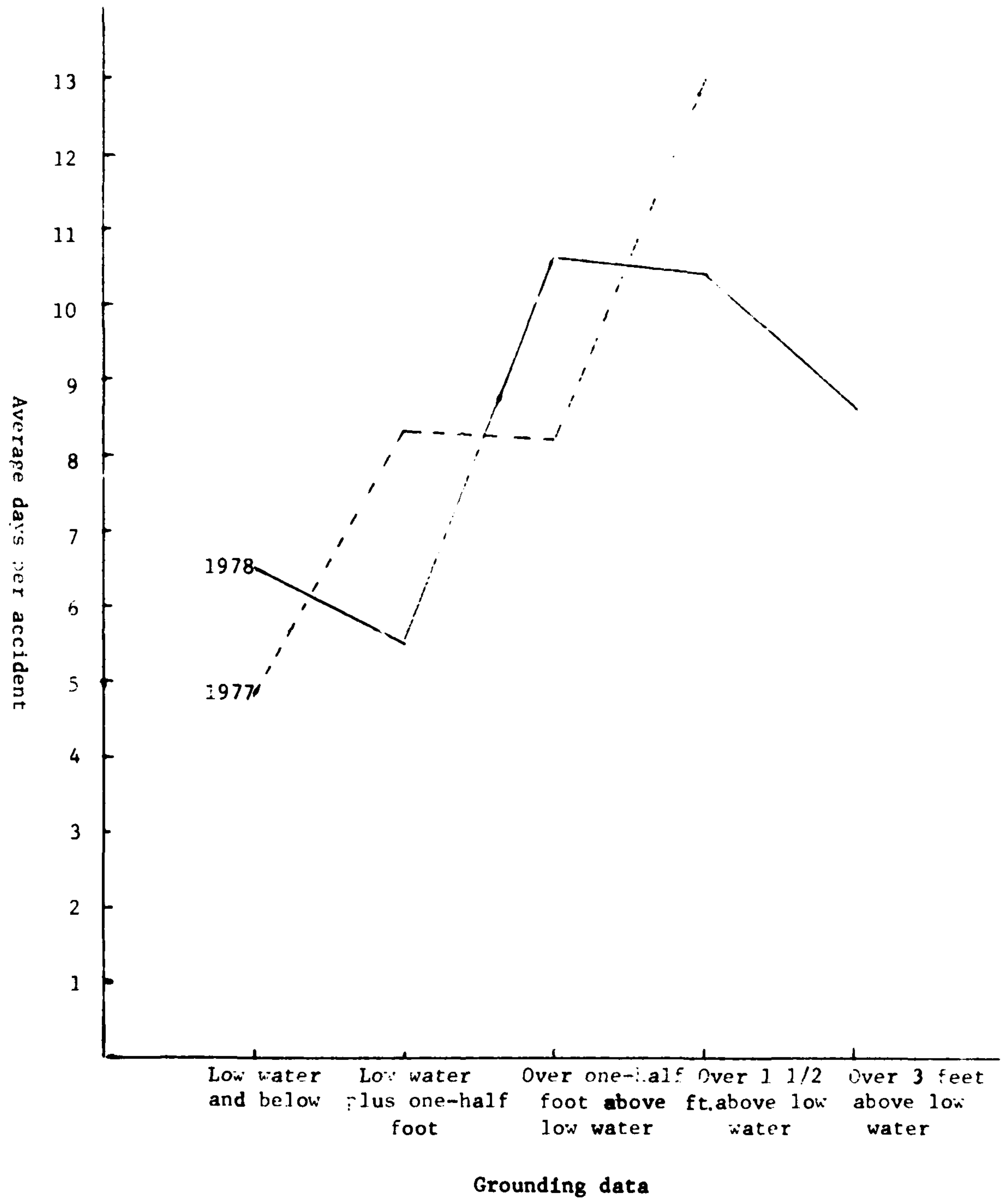
3. During high-water conditions, defined as 3 feet or more above normal pool, groundings increase but remain less than low-water conditions. Groundings at high water are affected by increased currents more than channel maintenance.

The following table and figure give grounding statistics for 1977 and 10 months of 1978.

Upper Mississippi River grounding rates at various water levels (1)

	Accident statistics					
	1977			1978 (10 months)		
Water level	Number of groundings	Number of days at water level	Days per grounding	Number of groundings	Number of days at water level	Days per grounding
Low water - below pool level 645.50	21	101	4.8	2	13	6.5
Low water and one-half foot above 645.50	38	301	8.3	20	98	5.6
Over one-half foot above 645.50	16	64	8.2	25	267	10.7
Over 1 1/2 feet above 645.50	1	13	13	16	167	10.4
Over 3 feet above 645.50	0	0	-	4	35	8.8

(1) The number of days for each water level is divided by the number of groundings that occurred with that water level. The result is the frequency that groundings will occur at the stated water level.



13
12
11
10
9
8
7
6
5
4
3
2
1
Average days per accident
1978
1977
Low water and below
Low water plus one-half foot
Over one-half foot above low water
Over 1 1/2 ft. above low water
Over 3 feet above low water
Grounding data

CAPACITY OF THE RIVER FOR COMMERCIAL TRANSPORTATION

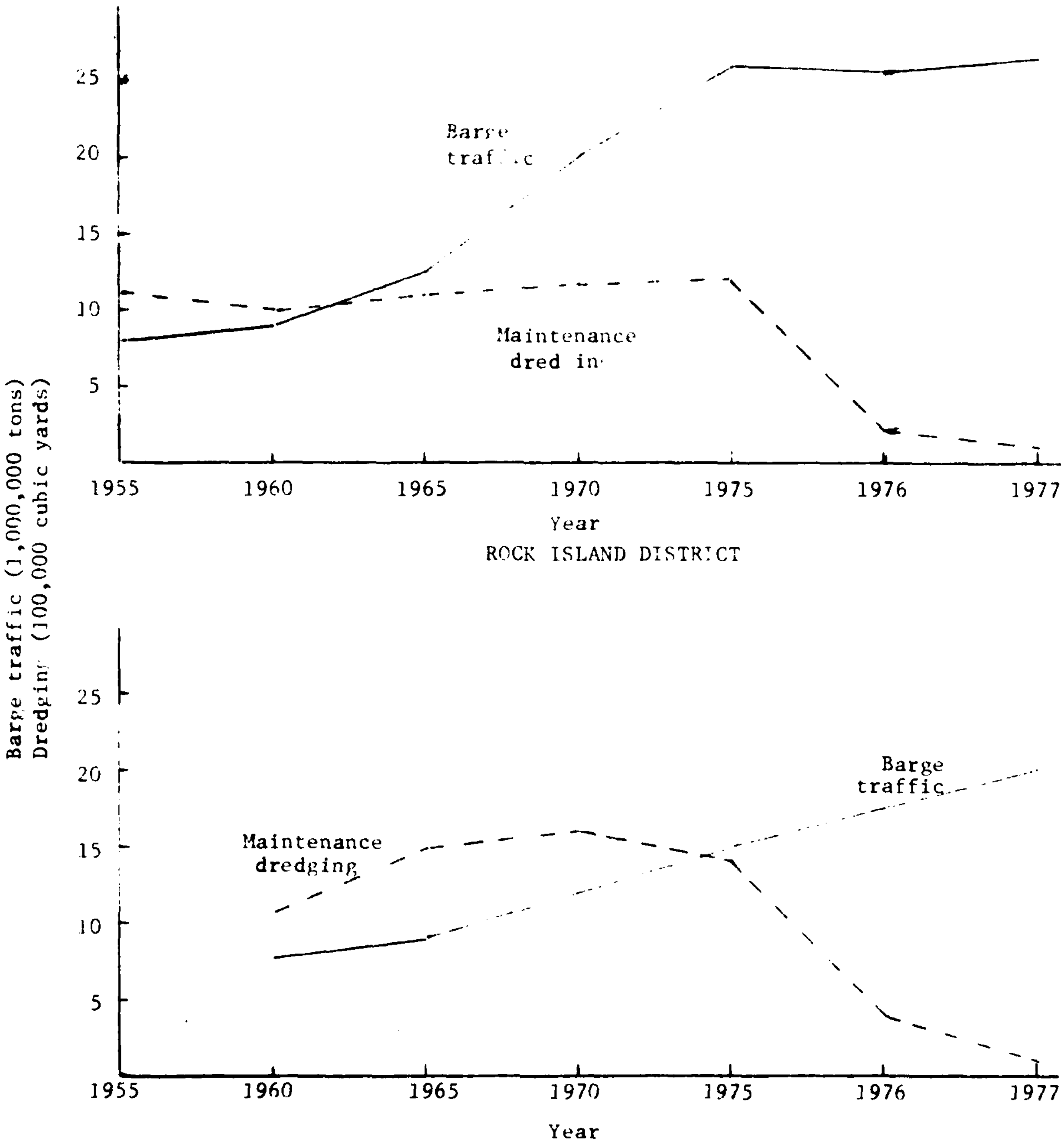
The existing river channel as a transportation corridor and navigation system is grossly underused. The transportation corridor refers to the full potential of the river while the navigation system refers to the river with existing constraints. One illustration of this underuse is to consider a 15-barge tow passing in either direction every hour during a 200-day navigation season. This number of tows would transport 100 million tons of cargo. One hundred million tons is more than five times the present volume of cargo being transported by barge into and through the St. Paul District. The fact that 100 million tons are not being moved is simply the result of limitations on either the supply of commodities being shipped, the market demand for these commodities, or nonmarket constraints.

River transportation is limited by its location and must depend on interface with other transportation modes to be effective. Therefore, only certain types of products, usually bulk commodities of local origin or required to support local power plants, industries, etc., lend themselves to barge transport. The market demand for these types of commodities is therefore limited by geographical area and transportation costs, as well as the supply of materials being shipped. For example, it is questionable if there is enough farm production in the GREAT I area to increase grain shipments five times over present levels. If for any reason, however, the present barge traffic level did increase by five times, the probable effect on channel maintenance would be relatively small (see the following figures). Locking capacity, fleeting areas and terminal capacity would have to be increased, but at a level far lower than five times present capacity because each of these facilities services many barges.

Further, river capacity cannot be determined by simply computing the number of barges that can be moved through the locks. Such calculations would provide theoretical values that would be excessively high because of all of the variable involved. There are also intrapool shipments that do not use locks.

The figures also reflect only lock capacity, and not river capacity. Should traffic exceed locking capacity, consideration should be given to expanding the lock capacity.

The Upper Mississippi River Basin Commission Master Plan Study required by Public Law 95-502 is attempting to determine the capacity of the navigation system. Although the work group did not intend to address this issue, available data indicate that the level of commerce on the river is far below what the river can support. Commercial transportation is a function of economic conditions and government policies operating in the free enterprise system.



Relation of maintenance dredging to commercial barge traffic, Mississippi River (averages for 5-year periods through 1975)

LEGAL AND INSTITUTIONAL FRAMEWORK (AGENCIES CONCERNED WITH ACTIVITIES RELATED TO COMMERCIAL RIVER TRANSPORTATION)

The following table describes activities in the GREAT I area in which various government and nongovernment agencies tend to regulate, control, plan, manage, or otherwise influence commercial river transportation. It was developed in response to one of the original tasks which was to "define the legal and institutional framework for commercial river transportation." It was generated "in-house" by the work group with primary inputs from the Iowa, Minnesota, and Wisconsin Departments of Transportation; St. Paul District, Corps of Engineers; and Second Coast Guard District. The development of a complete legal and institutional framework document was beyond the scope of an in-house activity. It is, therefore, considered a listing of government agencies who are concerned with and influence commercial river transportation activities.

It is quite evident from the information on the table that government controls a great many aspects of commercial river transportation which can result in duplication and delays.

Agencies concerned with activities relating to commercial river transportation

	Agency (1)			
Activity	Federal	Minnesota	Wisconsin	Iowa
Water use, flood control, recreation, fish and wildlife, drainage, treatment, and irrigation	Corps FWS EPA	DNR PCA MC RDC WPB SPA	DNR DOAG DLAD UWEX	CC NRC DSC IGS DEQ
Improvements of river, harbors, and waterways including dredging and harbor maintenance	Corps	MC RDC PA DOT PCA WPB DNR	DNR DOT DBD DLAD UWEX SHS	DOT NRC CC DEQ IDC DOAG OPP
Research, planning, and programming necessary for improvement of the river	Corps MARAD USCG	DNR DOT WPB DED PA	DOT DNR DBD SHS DOA UWEX DLAD	DOT NRC CC IDC SHD DEQ

Agencies concerned with activities relating to commercial river transportation (Cont)

Activity	Agency (1) Federal	Minnesota	Wisconsin	Iowa
Navigation requirements	USCG Corps	DNR PA	DNR	DOT
Rules and regulations governing the safety and security of ports	USCG FBI Corps	PSC PA	DNR	CC
Anchorage and movement of vessels within jurisdictional waters	USCG Corps			CC
Maintain search and rescue capabilities, life and property saving	USCG	DNR	DNR DLAD	
Establish and maintain aids to navigation (for example, short-range aids, marine information and communication services)	USCG FCC Corps	DNR	DNR	
Merchant vessel design requirements (for example, hull and system design)	USCG			
Commercial vessel inspection program	USCG			
Marine casualty investigations	USCG NTSB			
Bridge modification, permits and drawbridge regulations	USCG	DOT	DOT DNR	DOT
Program for merchant vessel documentation (for example, regulations and rulings and records and publication)	USCG MARAD			
Commercial vessel personnel (for example, documentation, licensing, and evaluation, vessel manning, and personnel requirements and qualifications)	USCG FCC			

Agencies concerned with activities relating to commercial river transportation (Cont)

Activity	Federal	Minnesota	Wisconsin	Iowa
	Agency (1)			
Rules and regulations concerning occupational safety and health on merchant vessels	OSHA USCG	DH		
Technical advise and assistance on incidents involving spills of hazardous and toxic materials from barges	USCG EPA	DNR PCA DH PA	DNR DLAD	DEQ CC NRC
Rules and regulations concerning occupational safety and health on shore facilities	OSHA USCG	DH PCA PA	DHSS	DH
Movement of hazardous material	USCG	DH PCA DNR DOT PA	DNR DOT DOA DLAD	DOT DEQ CC NRC
Commercial River transportation safety and transportation accident prevention	USCG NTSB			DOT CC
Barge terminal and fleeting permits	Corps USCG	DNR MC DOT PA DH PCA	DNR	NRC CC DEQ DOT
Weather, storm and flood warnings	NOAA-NWS Corps USCG		DLAD	DPD
Applications for mergers and consolidations	ICC SEC	COS SS PSC	SS DOAG DBD COS DOJ	SS
Rates and charges among competing and like modes of transportation for regulated movements	ICC	PSC DOT	TC DOR	DOT

Agencies concerned with activities relating to commercial river transportation (Cont)

Activity	Agency (1) Federal	Minnesota	Wisconsin	Iowa
Right to operate as regulated carrier	ICC	PSC	TC	DOT
Governmental actions to enhance and protect the environment	EPA USCG	PCA EQB SPA DNR MC RDC WPB	DNR DOT DHSS SHS UWEX DOJ DOA DLAD DOAG	DEQ DOT SHD CC IDC NRC DOAG DSC
Water and related land resources planning, development, and management	Corps UMRBC	DNR DOT SPA WPB RDC PA MC	DNR DOT DOAG DLAD DBD UWEX DILHR DOA	NRC DOT SHD CC IDC DEQ IGS DSC DOAG
Research and development activities to improve the efficiency and economy of the merchant marine and/or maritime activities	MARAD USCG OSHA Corps	DOT DED PA	DBD DOT	DOT DOAG IDC

(1) Agency abbreviations:

Federal

Corps - Corps of Engineers
EPA - Environmental Protection Agency
FBI - Federal Bureau of Investigation
FCC - Federal Communications Commission
FWS - Fish and Wildlife Service
ICC - Interstate Commerce Commission
MARAD - Maritime Administration
NOAA - National Oceanic and Atmospheric Administration
NTSB - National Transportation Safety Board
NWS - National Weather Service
OSHA - Occupational Safety and Health Administration
SEC - Securities and Exchange Commission
USCG - U.S. Coast Guard

State

CC - Conservation Commission
COS - Commission of Securities
DBD - Department of Business Development
DED - Department of Economic Development
DEQ - Department of Environmental Quality
DHSS - Department of Health and Social Services
DILHR - Department of Industry, Labor and Human Relations
DLAD - Department of Local Affairs and Development
DH - Department of Health
DHSS - Department of Health and Social Services
DNR - Department of Natural Resources
DOA - Department of Administration

Federal	State
	DOAG - Department of Agriculture
	DOJ - Department of Justice
	DOR - Department of Revenue
	DOT - Department of Transportation
	DPD - Department of Public Defense
	DSC - Department of Soil Conservation
	EQB - Environmental Quality Board
	IDC - Iowa Development Commission
	IGS - Iowa Geological Survey
	MC - Metropolitan Council
	NRC - Natural Resources Council
	OPP - Office for Planning and Programming
	PA - Port Authorities
	PCA - Pollution Control Agency
	PSC - Public Service Commission
	RDC - Regional Development Commission
	SHS - State Historical Society
	SHD - State Historical Department
	SPA - State Planning Agency
	SS - Secretary of State
	TC - Transportation Commission
	UWEX - University of Wisconsin Extension Service
	WPB - Water Planning Board

Many local government agencies and commissions also influence use of the river by commercial transportation.

River development must be accomplished in an orderly fashion to meet national, regional and local objectives. Good citizens and community members concerned with river transportation have complied with the letter and spirit of current laws. However, delays caused by improper administration of those laws impose unreasonable economic costs and constraints and are of grave concern to industry. The effects are not only felt by the individual citizens involved, but the entire country as well through the adverse impact on the economy. Attachment 5 of this report provides a case history that documents a 4 1/2-year process in obtaining a permit for a river terminal. The work group had many cases available, but selected this example to illustrate the problems encountered in the development process. Major points in the case history have been verified with people in, and out of, the GREAT study.

The cost figures presented in the case history include administrative costs and legal fees ($700,000) and increased construction costs ($7,000,000). The report does not address government agency costs, the loss of income to the applicant, the loss of jobs at the terminal for 4 1/2 years, or the loss of accompanying added economic activity in the community. Because the information was not available until the end of our study efforts, there was insufficient time for further investigation to identify all the ramifications of this case history.

The work group wishes to thank Mr. Thomas J. McMahon and Packer River Terminal for documenting their costly and frustrating experience.

PROBLEMS AND NEEDS

The work group originally established a task to determine problems and needs of commercial river transportation including barge fleeting areas, terminals and other support facilities. It solicited problems and needs from its own members, as well as from other interested parties. No party desiring input was excluded. As a result of this process, numerous problems and needs were identified. Because of the large number and wide variety, the work group, with the guidance of the Plan Formulation Work Group, culled and massaged the problems and needs into those items described in the following paragraphs.

Multitude of Regulatory Agencies

See the section beginning on page 41.

Fleeting Area Shortage

There are 27 designated barge fleeting areas in the GREAT I region with current Corps of Engineers fleeting permits. A listing and description of these is found in attachment 1.

In 1977, the work group conducted a survey within the barge and towing industry to obtain information regarding the adequacy of fleeting. The results are summarized in the following table.

Adequacy of fleeting areas in the GREAT I area

Adequacy	Area	Present capacity	Adequate or not
Critical shortage	St. Paul (1)	495	No, need 150 more spaces - will soon lose 60, so need 210 to meet near-term needs.
	Winona	15	No, need 45 more for near term.

Adequacy of fleeting areas in the GREAT I area (Cont)

Adequacy	Area	Present capacity	Adequate or not
	Clayton	0	Need 15 spaces now.
	McGregor	0	Need 30 spaces now.
Moderate shortage	Minnesota River	42	No, need 10 more spaces for safety during peak use.
	Red Wing	66	No, need 10 more spaces now; future needs may be double present capacity.
Adequate	Minneapolis	60	Yes, for now and long term.
	Prescott	55	Yes, for now and near term.
	Alma	23	Yes, for now and near term.
	Genoa	40	Yes, for now and near term.
Insufficient data	La Crosse	20	

(1) The indication of a critical shortage in the St. Paul area is supported by the Twin Cities Level B Study of the Upper Mississippi River Basin Commission.

The survey also indicated that the fleeting capacity situation will become worse as barge traffic increases. A summary of the growth in fleeting areas for the Twin Cities harbor from 1959 to 1976 indicated that footage had increased from 29,800 to 40,613 feet (see attachment 2). This is approximately 2.1 percent average annual growth and is substantially less than the growth in barge traffic.

A major cause of fleeting shortages is the difficulty in obtaining fleeting area permits. The Corps is the permitting authority but as part of its process it requests review of permit application by other interested Federal and State agencies. This review process can be quite lengthy and objection by a single reviewing agency is often enough for refusal of the permit. A second difficulty which contributes to the fleeting area shortage is that the permits are usually of a temporary nature and can be terminated on short notice whenever the landowner chooses.

In view of the foregoing, it is only logical to ask how the barge and towing industry is able to operate under these conditions. The excess barges are presently being accommodated by overloading the off-channel fleeting sites. This creates an economic hardship on the barge and towing industry. Those costs, however, are ultimately passed on to the consumer through higher shipping rates. In an overload condition, the fleeting site resembles a car parking lot that has cars filling the aisles as well as the stalls. The customer cannot get at his barge unless the aisles are cleared. Handling time and energy consumption are greatly increased.

Possible solutions to the fleeting shortage include, but are not limited to:

1. Streamlining the permitting process. The time required to process a permit should be reduced. More emphasis should be placed on the reconciliation of conflicts between the need for fleeting areas and environmental concerns by the States before commenting on permit applications. The State of Washington has a very successful "one stop" or "umbrella" permitting system that expedites the permit and minimizes confusion for the applicant.

2. Conducting a study to identify potential fleeting areas. The work group was divided as to whether the State Departments of

Transportation or industry should take the lead in this study. All agree that, in either event, a most important element of the study would be cooperation and coordination between industry and government. The results of a study of this nature would be useful in the permitting process to indicate acceptable alternatives in selecting fleeting areas.

The effect of barge traffic and fleeting areas on the environment has been raised as a concern by the Public Participation Work Group and is often raised as an objection to the granting of fleeting area permits. The Commercial Transportation Work Group views this as an important issue and will attempt to obtain more data in the GREAT II or GREAT III study area. In the absence of definitive studies, however, the issue appears to be based on emotion rather than facts.

Conclusions that can be drawn from studies by Dr. D. Warner of the University of Minnesota and Dr. M. Barloon of Case Western Reserve University are that barge fleeting activities or barge movements have little impact on wildlife. Dr. Warner has determined that black-crowned heron populations in the Pigs Eye Lake fleeting and industrial park area of St. Paul increased 58 percent for 1973 to 1978. During this period, the area also experienced extensive industrial development and fleeting growth.

Dr. Barloon's studies show that during a 25-year period barge traffic increased 5.7 times on the Upper Mississippi River while migrating duck populations increased 5.8 times. His studies also show a growth in bald eagle populations on the upper river from 1962 to 1975 of over 170 percent. During the same period, barge tonnage increased by 65.6 percent. The work group feels that, although some of the bald eagle population increase may be attributed to improved inventory techniques, the truer indicator is the percentage of immature eagles which has increased by 50 percent.

Dr. Calvin R. Fremling states: "We probably have more pounds of fish per linear mile in the Mississippi River now below Lake Pepin than we had when the white man arrived." He further notes, "It is not unusual to catch 10 or more species of fish in one day." The work group notes that casual observations of where fishing is best would also indicate that barge fleeting areas are a favorite site with many fisherman.

Width of Constrictions at Bends

The original intent of the work group was to address the matter of width constriction at bends as being an impediment to safe navigation of barge tows. As a related effort, however, the Dredging Requirements Work Group investigated ways to minimize dredging quantities and had identified bend width reduction as a possible action which could greatly reduce the dredged quantities. With the dual purpose of obtaining an insight into these two areas, the Commercial Transportation Work Group conducted a survey of 10 experienced rivermen. They were asked to examine 88 sites and indicate if/where/how large a width change should be considered. All of the rivermen were licensed master pilots with first-class pilot licenses; they represented over 250 years of experience, 181 of which were on the Upper Mississippi River.

The survey indicated that some changes may indeed be possible and still meet navigation needs. A detailed listing and description of the sites considered, pertinent definitions, evaluation parameters, and suggested widths is provided as attachment 3. The survey did not take into account increased bend widths that might be required for streamflow, to prevent erosion or shoaling, or for other needs. The following table summarizes those areas for which changes could be considered. The work group refrained from recommending that the changes be implemented immediately. The primary reason was that further review by representatives of the barge and towing industry, environmental interests, and the Corps was needed. In particular, it was felt that no change to traditional channel maintenance practices should be implemented until the proposed change and its expected effects are clearly described and discussed through some public medium where interested parties are given the opportunity to provide comments. The work group recommends that bend widths be determined by mathematical formulas such as those contained in Corps of Engineers Technical Letter 1110-2-225 dated 1 July 1977. Changes in bend widths or channel alignments should not be instituted without first obtaining input from licensed tow boat operators and the towing industry; for example, the Upper Mississippi Waterways Association and American Waterways Operators. Their knowledge of the river and its many operational characteristics cannot be ignored and is better than any intuitive decisions made by persons less familiar with barge and towing technology.

Possible bend width changes				
		Channel width (feet)		
Area	River mile	Present(1)	Change	Suggested
Increased width				
Grey Cloud Slough	827.3-828.0	400	+50	450
Boulanger Bend	820.3-821.5	450	+50	500
Truesdale Slough	808.2-808.8	350	+50	400
Four Mile Island	807.2-807.8	450	+50	500
Head of Lake Pepin	785.2-785.6	450	+50	500
Reads Landing	762.4-763.3	450	+50	500
Below Reads Landing	761.5-762.5	450	+50	500
Mule Bend	747.8-748.8	450	+50	500
Betsy Slough Bend	731.0-731.7	450	+50	500
Reduced width				
Boulanger Bend Lower Light	818.4-820.3	450	-50	400
Below Wind Creek	800.0-800.7	500	-50	450
Crats Island	758.0-759.5	500	-50	450
Below West Newton	746.4-746.9	500	-50	450
Winters Landing	708.0-709.0	500	-100	400
Broken Arrow	695.8-696.8	500	-50	450
Sand Slough	694.4-695.2	600	-100	500
Brownsville	689.7-690.2	500	-50	450
Island 126	677.2-678.2	500	-50	450
Bad Axe Bend	674.0-675.0	600	-150	450
Lansing Upper Light	663.8-665.0	600	-100	500
Below Lansing	600.3-661.0	600	-100	500
Gordons Bay	645.5-643.5	600	-50	550
Mississippi Gardens	642.5-643.5	550	-50	500
Wyalusing Bend	628.6-629.3	600	-100	500
Wyalusing	627.2-628.0	600	-100	500
Ferry Slough	615.6-616.3	600	-150	450

(1) After dredging.

Despite the placement of buoys by the U.S. Coast Guard, waterways are not analogous to highways with white lane dividers, reflectors, safety shoulders, and the like. To navigate a vessel in restricted channels requires a great deal of skill under a wide variety of conditions such as river current, shoaling, water depth, wind, visibility, and vessel maneuvering characteristics. While the most skillful pilot can handle most of these conditions without difficulty, the river navigation system, as with any operational system, must be designed to accommodate all levels of expertise. Even though towboat operators are tested and licensed by the Coast Guard, their experience and judgmental levels will vary. The work group feels that any scientific method of determining bend widths should be tempered with practical experience.

Legislation for River Uses Other than Commercial Transportation

The work group originally identified a need to address legislation preserving, protecting and enhancing river uses other than commercial transportation. The National Environmental Protection and the Endangered Species Acts have been cited by some as examples of legislation and concurrent rules, regulations, and government decisions being made without adequate knowledge of the effects.

The work group did not attempt to address this problem on a sweeping national scale. It narrowed its field of interest to the GREAT I geographic area, and then even further to GREAT I activities. The primary focus of attention was subsequently oriented toward GREAT I's channel maintenance activities.

In 1978, the Minnesota Pollution Control Agency required that water from the Corps dredging and disposal operations meet its effluent standards. This requirement is an example of a guideline that has been promulgated without a full understanding of the consequences. Not until after lengthy discussions and threat of closing of the Mississippi River to commercial navigation in the GREAT I area was the conflict resolved. The Pollution Control Agency's guidelines were established without determining the effect they might have on the ability of the Corps to maintain the navigation channel.

In summary, legislation and subsequent government activities and court decisions which are aimed at or closely related to preserving, protecting and enhancing river use for recreational, commercial, and environmental purposes should ensure that adequate trade-off and benefit-cost studies are performed before implementation, and that these studies ensure that the expected effects are clearly identified and discussed via appropriate public forums. This recommendation is not intended to exclude pilot projects aimed at obtaining data; however, the conclusions, methods, and recommendations of the pilot projects should not become operational until all needed studies are completed, reviewed and adopted.

Industrial Riverfront Development Constraints

Because of limited funding, the work group was unable to address the problem of riverfront development constraints to the degree necessary to generate alternative solutions. Its approach therefore was to develop a brief description of a study to address the problem and generate such solutions. The objective of the proposed study would be to identify constraints on the development of new or expanded commercial shore facilities and develop recommendations for the amelioration of those constraints. Four such constraints are:

1. Inadequate harbor capacities (for example, caused by inadequate access channels or natural conditions such as sedimentation and ice).

2. Inadequate terminal facilities (for example, caused by excessive requirements to obtain or retain a permit).

3. Excessive legal and institutional requirements on the commercial transportation industry (for example, equipment and personnel safety requirements, antipollution requirements and penalties, fleeting and terminal permit requirements, and floodplain related requirements).

4. Lack of effective intermodal relationships to efficiently move commodities.

The study approach would be as follows:

1. Using the constraints listed above, develop a comprehensive listing of constraints which act to restrict the development of new or expanded commercial shore facilities.

2. Analyze each of the constraints defined in step 1 in terms of the present situation to identify specific problems in the GREAT I geographic area. For each problem, identify alternative solutions and also the effects (economic, environmental, and social) of resolving and not resolving the problem.

3. Repeat step 2 in terms of the future. Predictions of the future situation should be obtained as considered most appropriate; however, those used in the University of Minnesota study should receive serious consideration.

4. Using the results of steps 1 and 2, develop recommendations for the amelioration of constraints on the development of new or expanded commercial shore facilities which will most effectively improve the commercial transportation system (multimodal) of the Upper Mississippi River. Describe the expected effects and the responsible party for implementing each recommendation.

Commercial and Recreational Traffic Conflicts

The Commercial Transportation and the Recreation Work Groups identified commercial and recreational traffic conflicts as a problem area which should be addressed. To avoid duplication, the Commercial Transportation Work Group deferred a formal addressing of the problem to the Recreation Work Group and encouraged its members to provide their inputs accordingly. Additional pertinent information can be found in the Corps Upper Mississippi River Small Craft Locks Study.

Bridge Clearances

One of the most troublesome problems of commercial navigation in the GREAT I area is the lack of adequate vertical and horizontal clearance at bridges. Bridges not only cause a safety hazard in limited clearance, but also cause costly delays because of normal operation or casualties. Rail and highway users are also affected by bridge operation and casualties. A listing and brief description of the 57 bridges across the Mississippi River in the GREAT I area can be found in the Coast Guard publication, Bridges Over Navigable Waters of the United States. In general, those bridges which cause the major problems to commercial river transportation are those of the movable or drawbridge type. In the GREAT I area, there are 10 of these bridges, shown in the following table:

Drawbridges in the GREAT I area

Miles above mouth	Bridge location	Owner	Type	Traffic	Clearances at normal pool level (feet) Horizontal	Vertical	Date Permitted	Completed
Mississippi River								
699.8	La Crosse, Wisconsin	Chicago, Milwaukee, St. Paul & Pacific Railroad Co.	Swing	Rail	150	21.9	Jul 1926	May 1928
723.8	Winona, Minnesota	Chicago, Milwaukee, St. Paul & Pacific Railroad Co.	Swing	Rail	200	20.5	Jul 1890	1891
725.8	Winona, Minnesota	Chicago and North-western Railroad Co.	Swing	Rail	151	21.4	Jul 1927	Jan 1930
813.7	Hastings, Minnesota	Chicago, Milwaukee, St. Paul & Pacific Railroad Co.	Swing	Rail	106	21.9		1871
841.4	Omaha Bridge, St. Paul, Minnesota	Chicago and North-western Railroad Co.	Swing	Rail	160	22.3	Dec 1927	May 1948
830.3	Inver Grove Heights, Minnesota	Chicago, Rock Island, and Pacific Railroad	Swing	Highway-Rail	195	19.4	Feb 1894	1895
835.7	Newport, Minnesota	Chicago, Great Western Railroad	Swing	Rail	180	20.6	Feb 1909	1910
839.2	St. Paul, Minnesota	Chicago and North-western Railroad	Vertical lift	Rail	158	25.1	Nov 1924	1925
Minnesota River								
14.2	Savage, Minnesota	Minneapolis, North-field and Southern Railroad Co.	Swing	Highway-Rail	103	20.3		Sep 1907
St. Croix River								
17.3	Hudson, Wisconsin	Chicago and North-western Railroad Co.	Swing	Rail	132	17.1		1922

Reference: Department of Transportation/U.S. Coast Guard, Publication CG-425-2, Bridges Over Navigable Waters of the United States.

Because of their age, many of the drawbridges suffer from frequent mechanical breakdowns, sometimes closing the channel to commercial river transportation for days and even weeks. Bridge passage requires slow, precision navigation. Even with all due caution by tow operators, vessels collide with bridges damaging the bridge as well as the tow. When a bridge is damaged, the channel is often closed or restricted so repairs can be made. Because drawbridges pass traffic only one way at a time (that is, land traffic over the bridge or water traffic under the bridge), conflicts frequently occur over who gets priority.

Some of the impacts to navigation caused by obstructive bridges are hours of delay, expenses incurred during and as a result of delay, fuel consumed, damages to tows and bridges, and personal injury. These impacts were not quantified because of time and funding constraints, but have been partially addressed in the GREAT II study. Even though specific information was not available in GREAT I, the work groups felt the situation was serious enough to warrant the conclusion and recommendation that aggressive action should be taken to remove or replace restrictive bridges in the GREAT I area. Replacement structures should comply with current Coast Guard guidelines as to vertical and horizontal clearance. These guidelines are:

1. Vertical clearance. - From the mouth of the Illinois River up to St. Paul at mile 853, the minimum vertical clearance should be 52 feet above the 2-percent flow line or 60 feet above the flat pool, whichever is greater. The 2-percent flow line is defined as the water surface elevation that is not exceeded more than 2-percent of the time. From St. Paul at mile 853 and up to the head of navigation at mile 857.6, the minimum vertical clearance should be 21.4 feet above the water level which would occur from a flow of 40,000 cfs (cubic feet per second).

2. Horizontal clearance. - The horizontal clearance should be developed empirically by combining the practical experience and knowledge or river pilots, bridge builders, the States, the Coast Guard, and the Corps of Engineers. Among other things, the process should include on-site evaluation

which would involve real life, practice approaches and traverses of the river area by tows and other boats. Decisions on horizontal clearance would be strongly influenced by characteristics of the river at the proposed bridge location; for example, bend vs. straightaway, prevailing wind and current characteristics, and visibility.

Bridges that obstruct navigation because of original design features or changes in the volume of traffic or vessel sizes may be rebuilt under the Truman-Hobbs Act. This act provides for cost-sharing between the Federal Government and the bridge owner. The speed with which an obstructive bridge is replaced depends on the availability of funds and the priority of the project within the bridge rebuilding program. The Hastings Railroad Bridge was declared obstructive to navigation in 1948 and will receive funds in 1979. A bridge on the Illinois River received funding in 3 1/2 years; however, the average is somewhere between the two examples. One important aspect of the Truman-Hobbs Act is that only benefits to the marine industry are calculated in establishing the benefit-cost ratio for the project. It is therefore recommended that, because public money is being spent, the total benefit to the public be considered in the benefit-cost analysis. It is further recommended that protective fendering systems and sheer walls required to protect the bridge and facilitate vessel passage also be included for Truman-Hobbs funding.

Action is being taken which will affect at least two of the bridges - the Hastings Railroad Bridge at mile 813.7 and the Chicago and Northwestern Railroad Bridge at mile 725.8. The Hastings Railroad Bridge is the oldest of the GREAT I drawbridges and was completed in 1871. It has the least vertical and horizontal clearance and is probably the most serious impediment to safe, efficient navigation. The Coast Guard has acted under the authority of the Truman-Hobbs Act to declare the Hastings Railroad Bridge an unreasonable obstruction to navigation.

The work group recognizes that fixed and movable bridges will continue to present restrictions to navigation. In accepting a bridge permit, the bridge owner agrees to comply with regulations governing the construction and operation of the bridge to minimize the obstruction to navigation. The work group also felt that existing regulations governing the operation of drawbridges provide for the reasonable needs of navigation, but must be vigorously enforced. Those regulations, enforced by the U.S. Coast Guard, provide only for criminal penalties when the bridge owner or operator is in violation. The imposition of criminal penalties for minor offenses, and even some of the more serious ones, is not pursued because of the low priority assigned to this area by the U.S. Attorney's office. As a result, the Coast Guard is effectively powerless to enforce bridge regulations. It is therefore recommended that present laws be amended to provide for administrative penalties for the less serious violations. This action is intended to include bridge lighting, fendering systems, sound signals, etc., as well as the actual operation of the draw span.

Channel Closure and Dredging Techniques

As originally stated, this problem/need was to identify the impact of channel closure and various dredging techniques. These two impact areas are described separately below.

Channel Closure. - The most immediate impact of channel closure is easy to identify - the tows stop moving. Closure may be in terms of minutes or hours as might be caused by failure of a drawbridge to open on the approach of a tow, or in terms of days or weeks as might be caused by inadequate dredging or inoperable locks or bridges. Any river shutdown will have an adverse effect ranging from low cost/nuisance to high cost/economic disaster.

An estimate of $200 per hour is a conservative figure for operating a typical Upper Mississippi River towboat and is exclusive of barge costs. However, it is misleading to simply multiply this figure (or any fixed figure for that matter) by the number of hours delay to obtain the total cost of delay.

A theoretical example which illustrates the impropriety of such a process would be that of a shipper who has a contract to deliver a load of grain in New Orleans, Louisiana, by a set date. He buys the grain at a good price in St. Paul and ships it down the river. However, the channel is blocked at Reads Landing. To meet his commitment and/or avoid a contractual penalty, the shipper purchases grain downstream at a high price and delivers it on schedule. Meanwhile the channel is finally cleared after a week's delay (7 days at $200 per hour = $33,600) and the tow arrives in New Orleans with a load of grain for which the owner has difficulty finding a buyer and ends up selling at a price below what he paid. Finally, being 7 days late arriving in New Orleans, the carrier has missed a return shipment and must deadhead back to St. Paul without revenue to get his next shipment. Obviously, the cost of the channel closure would be substantially more than indicated by the $200 per hour figure.

Another aspect of channel closure is that closure, especially when caused by inadequate depths, is usually undetected until a grounding occurs. When that happens there are risks of personal injury, vessel damage, and cargo spillage or pollution. These factors should be considered in assessing the impact of channel closure.

It is clear that channel closures create detrimental impacts. Prudence dictates that channel closure should be stringently avoided and that pressures and conditions which tend to increase the risk of closure should be resisted.

Dredging Techniques. - The work group has consistently expressed an interest in riverine disposal because it may be the most effective method. Riverine disposal in our view is defined as deep water or main channel disposal where the material is placed back into the river transport system. However, riverine disposal is not hydrologically feasible in all locations.

Data available from the Waterways Experiment Station (WES), Vicksburg, Mississippi, indicate that the environmental effect of riverine disposal is short-lived. There is also some sentiment that the environmental effects of dredged material in the water are less than the effects of on-land disposal.

Riverine disposal accomplishes what the river does naturally. A case in point is the Gordon Ferry dredge cut where dredging plans called for the removal of 60,000 cubic yards of sand. While the Corps of Engineers and GREAT were debating where the material should be placed, river conditions changed and 500,000 cubic yards were removed from the area by the river itself. Riverine disposal does not affect the floodplain, resuspends but does not add any new materials to the water, and does not affect fish and wildlife any more than natural river movements, particularly since dredging accounts for a small percent of the material transported in the river. It may also be the least costly method to the taxpayer by eliminating transportation and handling costs.

Historically, the St. Paul District has used the Dredge William A. Thompson and Derrickbarge Hauser to maintain the navigation channel. The Hauser uses a crane and clamshell bucket. It is primarily employed in the Minneapolis-St. Paul metropolitan area where disposal site limitations and bridge clearances preclude use of the Thompson. The Hauser also performs maintenance dredging in Mississippi River small-boat and commercial harbors, performs channel maintenance dredging and snagging on the Minnesota River, and makes wing dam modifications when required. The normal operation is to dredge the material from the channel and place it in dump scows. The loaded scows are moved by a tender to a disposal site away from the dredge cut. Because the dump scows' draft is approximately 6 feet when loaded, the material is dumped in a minimum depth of 6 feet and cast on land, if required, by the Cranebarge Wade. The material is distributed with dozers as required. The normal capacity of the Derrickbarge operation is approximately 2,400 cubic yards per day.

The Thompson is a hydraulic dredge with a minimum bridge clearance of 52 feet 9 inches. It performs the bulk of the dredging in the St. Paul District and is also used in the Rock Island District. The normal mode of operation is to sweep the channel with its intake pipe and pump the material as a slurry of approximately 20- to 30-percent solids and 70- to 80-percent water to a disposal site away from the dredge cut. The material is distributed with dozers as required. The normal capacity of this operation is approximately 17,000 cubic yards per day. In 1975, the Corps acquired the Dredge Mullen and converted it to a boosterbarge for use primarily with the Thompson. With the booster, the Thompson can reach disposal sites up to 1 mile from the dredge cut. The St. Paul District has also investigated other dredging equipment and techniques including 12- and 8-inch hydraulic dredges.

From a purely navigation point of view, it is relatively unimportant which dredging technique is used so long as it maintains a navigation channel of adequate size and configuration to handle commercial river transportation. However, from a broader point of view it is of major importance that the selection of dredging techniques gives significant consideration to commercial river transportation for the following reasons:

1. The Corps receives a limited amount of resources to perform its many missions. Excessive and/or unnecessarily high cost of dredging may reduce its ability to maintain the 9-foot navigation project.

2. Unnecessarily high dredging costs detract from the economic benefit of the 9-foot navigation project.

The work group did not attempt to evaluate the cost of alternative dredging techniques. Such an evaluation would involve alternative disposal techniques and the resulting range of dredging disposal alternatives would require a major effort beyond the work group's resources. However, it is clear that dredging techniques do affect commercial river transportation, and that the area of impact is primarily economic. The selection of the most appropriate dredging technique should take into account and give careful consideration to these economic impacts.

MISCELLANEOUS ACTIVITIES

Channel Maintenance

As a result of its origin in the Wisconsin lawsuit over dredging and disposal practices, but at slight variance with the Water Resources Development

Act of 1976, Section 117 mandate for a river system nanagement plan, most of the attention of the GREAT I Team and Plan Formulation Work Group focused on channel maintenance. In particular, significant efforts were made to develop material placement plans and guidelines for channel maintenance dredging and disposal.

Material Placement Plans. - The purpose of these plans was to make 50-year estimates of the volume of dredged material which would require disposal and identify specific disposal sites which were agreeable, or least objectionable, to all interested parties and would handle the estimated volumes. It was hoped that this advance type of homework and planning would ameliorate previous disposal related problems.

The primary work group involvement was to generate criteria for evaluating proposed disposal sites and to use the criteria for evaluating specific sites. The criteria developed are:

1. Will the site physically impede navigation such as by obstructing maneuvering space or visibility?

2. Will the site infringe on existing or proposed barge fleeting or terminal areas?

3. Will the channel characteristics or the disposal site change the river's flow characteristics and impede navigation, undermine structural foundations, or impair the placement and/or station keeping of aids to navigation?

4. Will the site pose a navigation-related hazard to the safety of life and property not covered by the above items?

5. Will the site involve costs which are greater than would have existed without GREAT? Of specific concern are Corps land use acquisition costs, material transportation costs, and site preparation/maintenance costs.

These criteria were applied to over 200 sites. They were used to determine, from the point of view of commercial river transportation, whether a site should be accepted. If any question was answered yes, the site may not have been acceptable. It was not automatically rejected but it w examined more carefully and thoroughly.

Adequate information was not available to assess the increased costs associated with the disposal sites being recommended by GREAT. It was also important to identify increased costs as they would affect the general economic condition of the area, ability of the Corps to maintain the channel within available funds, and taxpayers in general.

Establishment and maintenance of the 9-foot navigation channel was based on an economic need and the benefits that would accrue from such a project. Navigation projects should, and are now required by law to, consider the effects of the project upon the environment. Likewise, environmental projects and concerns should not be insensitive to the economic impact of their demands. The interests of both groups ultimately affect people and the quality of life. The work group felt it was imperative to include criterion 5 involving costs. The work group recognizes the difficulty in assigning monetary figures to environmental factors, but feels strongly that a value judgment must be made in considering the environment vs. economic projects. Of the 200 sites evaluated by the work group, only criteria 1 through 4 could be applied with available information and all of those criteria met with approval.

Guidelines for channel maintenance dredging and disposal. - For the 1977 and 1978 dredging seasons, the GREAT I Team provided a set of recommended guidelines to the Corps for its channel maintenance dredging and disposal activities. From the work group's point of view, these guidelines were biased in favor of environmental concerns and against economic and navigation concerns. Accordingly, the work group attempted to redress this situation by independently developing a separate set of guidelines for consideration by the Team in future revisions to its recommendations or for independent adoption by the Corps. The work group's "Guidelines for Channel Maintenance Dredging and Disposal" are included in attachment 4.

Suitability Models

The GREAT I Plan Formulation Work Group asked the Commercial Transportation Work Group to participate in its "suitability model" project. The system could be useful, but fell far short of meeting the Commercial Transportation Work Group's needs. The inflexibility of the system in meeting all river resource needs will present incomplete and distorted information.

The project was a pilot study focusing on pools 4 and 5, which placed appropriate information into a computer attempting to generate maps showing geographic areas which are most suitable for various uses. For example, the computer model could supposedly be used to generate a map of those areas in pool 4 which are most suitable for barge fleeting areas. Accurately done, this type of information could be very useful to navigation interests. Similarly, the computer could generate maps for other uses such as duck brooding habitat or boat access. Subsequently, various planners could compare the computer-generated maps to identify areas which appeared to be suitable for multiple, but conflicting, uses. With this information, the planners could resolve the conflicts and proceed more effectively in developing plans for the use of the land and water areas. Hence, the "suitability model" pilot project was a step toward the long range goal of having a management tool to assist in making decisions on land and water use planning and zoning. The project was cofunded by GREAT I and the U.S. Fish and Wildlife Service and contracted to Environmental Systems Research Institute. The project title was originally "Computer Inventory and Analysis" but was subsequently changed to "Geographic Information System."

The work group had strong concerns over the increasing intrusion of government into land and water use management and control and noted that the proposed suitability model project is becoming a part of that process. Accordingly, work group involvement in the project should be taken neither as support for increased governmental management and control, nor as support for the land

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2. The computer data base has either no or inadequate information on land ownership, water depth, rail adjacency, existing land use, existing or planned use regulations (for example, floodplain restrictions), surface geology, and wing dam locations.

3. It is almost impossible to define, much less evaluate, all the criteria and relationships necessary for selecting areas most suitable for terminals and fleeting areas. Those included in the models are inadequate at best.

In spite of the problems, the work group developed the desired "prototype plan" but inserted a strong warning that it was strictly hypothetical. It should not be considered to reflect any realistic world situation or projection. The prototype plan projected a need for four new terminals and supporting fleeting areas. Four separate types of terminals were considered: grain, tank farm, coal, and dry bulk. Typical criteria were identified for each. The contractor provided maps of those sites which the computer deemed suitable for terminals and fleeting areas. The work group task force evaluated each site and selected first, second, and third priority locations and appropriate fleeting areas for each of the projected new terminals. Finally, work group and contractor representatives met to discuss the results of each work group's "prototype plan" and develop a process for conflict resolution.

Barge and Recreation Craft Safety

The Recreation Work Group reviewed Coast Guard and State accident reports and determined that 5.3 percent of the accidents on the Upper Mississippi River between 1970 and 1977 were between barges and recreational craft. This statistic reduced to actual numbers shows the annual accident rate is only 1.12 barge/recreation accidents per year. The analysis also shows that 73 percent of all accidents occur between 8 a.m. and 8 p.m.

and water use management tool which is the apparent result of the process begun by the "suitability model" project. Rather, the rationale for work group involvement was that the project itself, as well as follow-on development, would probably proceed with or without work group participation. The work group's intentions were to ensure that the needs of commercial transportation were incorporated as adequately as possible.

In the fall of 1977, members of the work group met with the Fish and Wildlife Service and Environmental Systems Research Institute to prepare input for the Geographic Information System program. Work group related concerns included construction suitability factors, rail and road adjacency, water adjacency for terminals, and land adjacency and certain safety factors for fleeting areas. These criteria were modified in early 1978 after a test run of the program.

In the spring of 1978, the suitability models were ready for a more detailed test run and evaluation. The work group was requested and agreed to develop a prototype plan for commercial navigation for the pool 4 area. The idea was that this work group's information could be used with the computer-generated information to determine both strong and weak points in the suitability models.

The pilot area was not well suited to test commercial transportation needs because:

1. The land and water areas in pools 4 and 5 are heavily oriented toward fish and wildlife uses. These areas have a relatively small population and industrial base with only one terminal and fleeting area and no apparent potential for further development. Also, transportation facilities (highway and rail) in the area are oriented in the north-south direction and do not provide for ready access between the hinterlands and this reach of the river. For example, the pilot project area lies between the two east-west major highways - Interstate 90 and Interstate 94. These highways and the rail system are the major carriers of commodities to the existing terminals in the GREAT I area.

Barge Tie-Off Procedures. - In response to a request from the GREAT I Public Participation and Information Work Group, the Commercial Transportation Work Group provided the following comments on the development of standard procedures for tying up barges in fleeting areas to prevent swingout into the channel. Barges infrequently adrift are also included in this section and are a much more severe problem in terms of potential damage. The majority of drifting barges result from vandalism when lines are unfastened or cut.

Many docks and terminals already have specific requirements on tie-off procedures. These requirements have been developed by the individual facilities over the years in response to their own particular requirements as affected by such factors as fleeting area configuration, river and weather conditions, and type of traffic. For example, the Victoria Elevator Terminal in Minneapolis Upper Harbor specifically requires two good 35-foot leaving lines, one upriver and one downriver lead line, plus a chain and padlock from the barge to the dock.

Because of the different conditions which exist at fleeting areas, it would be extremely difficult to develop a set of practical "standards" which could reasonably be applied to all fleeting areas. There are simply too many configurations to deal with.

Owners/operators of barges must report barges that are adrift to the Coast Guard and are subject to penalties in cases of negligence. Swingouts do not have to be reported. Hence, the owners/operators already have a strong incentive to avoid breakaways; this incentive is in addition to other positive incentives such as increasing profits by avoiding loss or damage to barges and cargo, increasing profits by avoiding extra costs from "recapturing" the drifting barge, and, finally, a general human concern for the safety of life and property.

The frequency of breakaways in the GREAT I area is very low. Only seven breakaways were reported to the Coast Guard over a recent 18-month period for Mississippi River between St. Paul and Keokuk, Iowa.

When a barge is adrift, local authorities, marine operators, towboat companies, etc., react to gain control of the barge and prevent damage. This emergency effort transcends company lines or individual interests.

In summary, it was the general opinion that requirements for tying up barges should not be standardized, but should continue to be determined by the trained and experienced judgment of barge and terminal owners/operators/etc., with continued monitoring by Federal and State agencies to detect unacceptable, hazardous situations.

Reflective Coatings for Barges. - In response to a request from the GREAT I Public Participation and Information Work Group, the Commercial Transportation Work Group provided the following comments on the feasibility of having reflective paint or material on the bow and sides of all commercial navigation vessels as an aid to safe nighttime navigation by recreational boaters:

1. Federal regulations prescribe specific lighting requirements for powered vessels (for example, towboats). Federal regulations also prescribe specific lighting requirements for barge fleeting/mooring areas. The use of reflective material may conflict with these regulations unless specifically authorized by the Coast Guard through normal rule-making procedures.

2. No evidence has been presented, nor is any known to be available, that substantiates the proposition that reflective paint or material on the bow and sides of all commercial navigation vessels would improve the safety levels of nighttime navigation by recreational boaters. (See the section on barge and recreation craft safety beginning on page 72.) In this same light, the Coast Guard maintains records of all reported accidents involving both commercial and recreational vessels and periodically analyzes the data to identify ways to improve safety levels.

3. The cost of preparing and covering a barge with reflective material just below the top knuckle is estimated to be more than $2,500. This figure does not include maintenance or loss of revenue caused by having the vessel out of service during the coating process.

4. Abrasion on lock walls or adjoining barges would make it very difficult to maintain the reflective material.

5. Paint manufacturers have indicated that film from the river water may build up and drastically reduce the effectiveness of the reflective coatings.

6. Night vision of both commercial and recreational boaters could be seriously impaired by the glare of a search light reflecting from the barge, thus causing a serious safety hazard.

7. The ability of a tow operator to see his deck hands' signals could be seriously impaired by the glare from the tow's search light reflecting from coated areas, thus causing a serious safety hazard.

8. Care must be exercised in selecting a coating that does not contain hazardous components which could pollute the river.

9. Reflective coatings on commercial navigation vessels may not be of use to recreational boaters. Boaters do not usually carry a searchlight. Furthermore, if a recreational boater has and operates a light, he would see the barges even if they do not have a reflective coating.

10. If reflective coatings were required, it would make more sense that they be on the recreational boats since most commercial vessels have and use searchlights.

11. It may be that accidents which occasionally occur between commercial navigation vessels and recreational boats are not caused so much by the inability of the boater to see the vessel, but to the boater seeing the vessel's lights and not understanding their meaning. In this respect, an increased program of boater education might be appropriate.

In summary, it was the general opinion that a program of boater education which emphasizes knowledge of the rules of the road, lighting requirements, seamanship and boat handling would be more effective than requirements for reflective coating.

Night Lighting of Barges at Docks and Fleeting Areas. - In response to a request from a private utility company with interests in barge operations, the work group provided comments relating to night lighting of barges at docks and fleeting areas. The problem presented was that the portable lights which the operators use to satisfy Federal regulations for night lighting of barge fleeting and mooring areas are continually being stolen or damaged by vandals. The loss of these lights leads directly to two adverse situations as follows:

1. The light must be replaced; the costs for materials and labor are significant.

2. During the period between the loss and replacement of the lights, the responsible party is subject to citation/punishment for failure to satisfy barge fleeting/mooring lighting requirements.

The work group developed a set of three alternative solutions to the problem. The selection of the most appropriate alternative should be at the discretion of the party with the problem.

Alternative 1: Alternative lighting procedures to meet existing legal requirements. - For example:

1. Permanently installed lights positioned on the barge and powered by replaceable batteries. This would probably reduce the loss of lights and batteries although the batteries would still be very susceptible to loss unless they were placed in a secured (locked, bolted, or chained) compartment.

2. Permanently installed lights and diesel electric power supply module, rechargeable battery storage bank, etc., positioned on the barge. This would probably be more secure than the example above, but would also be more expensive. It would also be operationally difficult to maintain.

3. Permanently installed lights positioned on the shore or on appropriate piers or pilings and powered from electric utility systems. This alternative is already in use on portions of the Chicago Ship Canal. However, it would require a special variance from Federal regulations.

Alternative 2: Increased surveillance/inspection of the barge fleeting/mooring areas to prevent loss. - For example:

1. Owner/operator/etc. could provide night watchmen.

2. State and/or local law enforcement agencies could increase the frequency of their partrols. Theft/vandalism is a violation of local/State laws.

3. The Coast Guard could institute patrols to detect violations of State and Federal law.

Alternative 3: Change the legal requirement for the lighting. - The Coast Guard promulgates vessel lighting requirements. Recommended changes should be submitted with detailed information to support the changes in terms of increased safety or more economical operation.

Recommended action. - Barge owner/operators/etc. should consider altering their lighting equipment or procedures as described in alternative 1. States and/or local authorities should investigate the problem within their jurisdiction and consider changes to their surveillance/inspection procedures as described in alternative 2. They should coordinate these activities with the Coast Guard.

If the above recommendations do not provide satisfactory results, alternative 3 should be considered.

Closed Navigation Season

The St. Paul District, Corps of Engineers, requested comments regarding the effects of an arbitrary closure of the navigation season caused by winter ice conditions on portions of the Mississippi River above Cassville, Wisconsin. The response of the Commercial Transportation Work Group was that it perceives no significant, beneficial effects for the barge and towing component of the commercial transportation industry that would result from establishing dates for the opening and closing of navigation on the subject portions of the river. However, it does foresee various adverse effects - for example, inability to use the river because it is closed by mandate, when in fact it is reasonably clear of ice. Therefore, the work group recommended that no arbitrary closing dates be set.

CONCLUSIONS AND RECOMMENDATIONS

This section provides conclusions and recommendations which are based on studies performed or the results of deliberations within the work group. Great I guidance mandated that work group representatives rely on their professional opinions and not agency or State policy. To the best of our ability, this tenet has been preserved.

While the main interest and concern of this work group is commercial transportation, we have tried to avoid tunnel vision in our thoughts and actions.

It should be pointed out that this work group received less than 3 percent of the GREAT I budget to conduct studies and develop solutions.

CHANNEL MAINTENANCE

Conclusion

The Corps has changed its channel maintenance dredging and disposal practices. Preliminary indications are that some environmental improvements have been made. However, various adverse effects have also resulted. Of particular interest to commercial navigation are changes to navigation channel dredging and disposal practices that have been implemented without first analyzing the direct and indirect consequences of those changes.

Riverine disposal may present the least cost and most environmentally desirable method of dredged material disposal.

Recommendation

1. Continued maintenance, preservation, and expansion of the navigation channel should be conducted to meet current and future needs of 9-foot draft vessels. Specific recommendations for implementation are contained in the work group's guidelines for channel maintenance dredging and disposal.

2. GREAT acknowledges that the guidelines and standards for channel maintenance as historically practiced by the Corps have provided an adequate navigation channel for 9-foot draft vessels. Before any changes or deviations from these practices are implemented, the risk of grounding, transit time, fuel consumption, cargo capacity, and dredging and disposal costs must be considered.

3. Congress should define the Mississippi River 9 foot navigation project as "including allowances required for advance maintenance dredging, dredging tolerances, squat and trim for the class of vessel for which the project was designed, wave action, shoaling rates, and other overdepth allowances necessary to afford safe navigation for vessels with a draft of 9 feet."

4. Riverine disposal should be considered as a viable alternative in formulating dredged material disposal plans.

5. Any GREAT recommendation referring to channel maintenance should include the historical costs and the additional costs resulting from that recommendation.

6. The Corps should maintain fiscal records and publish an annual report comparing the costs for historical and current channel maintenance practices.

NONCHANNEL MAINTENANCE

Conclusion

Commercial river transportation is a vital link in the total GREAT I transportation network.

Waterway commerce for the Upper Mississippi River has exceeded high growth predictions from Cairo to St. Paul every year since 1964 and exceeded predictions by 9½ million tons in 1974 (River Transportation in Iowa, Iowa Department of Transportation, May 1978).

Commercial transportation is a function of economic conditions and government policies operating in the free enterprise system and is far below what the river can support.

Traffic congestion at locks and dams 2 and 3 could become a serious problem during peak usage periods by recreational craft.

Recommendation

7. The Corps should make recommendations to Congress to alleviate projected capacity limitations at locks and dams 2 and 3 caused by demand increases. The Mid-America Ports Study, Recreation Lock Study, and GREAT I Recreation Work Group concerns should be considered.

Conclusion

Restrictive bridges are a major impediment to safe, efficient navigation and must be rebuilt to provide adequate horizontal and vertical clearances. Truman-Hobbs legislation is not flexible enough to meet current demands and public needs.

Bridge delays and other channel closures can be extremely costly. Those costs are ultimately passed on to consumers.

Recommendation

8. Obstructive bridges should be rebuilt to provide adequate horizontal and vertical clearances. The Truman-Hobbs Act should:

a. Continue to be used in rebuilding bridges on the basis of navigation needs.

b. Be amended to include replacement or repair of bridge protection systems.

c. Be amended to include benefits to land as well as marine interests. Because public money is being spent, the total public benefit should be considered in benefit-cost ratios.

9. Operating regulations for drawbridges must be vigorously enforced by the U.S. Coast Guard. To accomplish this, the acts of 18 August 1864

and 3 March 1899, the Bridge Act of 1906, and the General Act of 1946 should be amended to provide for civil penalties in certain circumstances and for other purposes as recommended by the U.S. Coast Guard.

Conclusion

The myriad of Federal, State, and local government agencies involved and/or regulations affecting water transportation, terminals and support facilities has resulted in duplication, contradiction, confusion and unnecessary delays. This is particularly evident in the obtaining of fleeting, terminal, and dredging permits.

Regulatory constraints on the development of new or expanded commercial shore, terminal, and support facilities have adversely affected the economy.

Recommendation

10. A comprehensive study should be performed to identify Federal, State, and local regulatory activities applicable to river transportation. The study should identify areas in which Federal laws and agencies must supersede State and local regulatory activities and develop recommendations to eliminate the contradiction and intrusion by State and local government into the Federal domain of interstate commerce.

11. A study of contraints on the development of commercial facilities should be conducted to evaluate their net cost and benefit to the public.

Conclusion

Work group studies have indicated that:

a. By 1985, total downbound barge shipments in the GREAT I area will increase substantially over 1975 levels, primarily as a result of increased agriculture products.

b. Existing problems, such as fleeting shortages and locking wait times, will intensify.

c. No new problems caused by increased traffic are foreseen.

The imposition of any user charge on water transportation will increase shipping costs for GREAT I residents. Farmers would be most affected because farm commodities account for more than half of the barge ton-miles. In 1985, on the basis of current predictions, the fuel tax will result in increased cost of over $4.8 million at a rate of $0.08 per gallon.

GREAT I studies have not identified all of the users and beneficiaries or uses and benefits that result from a navigation project in the GREAT I area.

Recommendation

12. Beneficiary/user data should be developed and used by appropriate agencies in managing water resources and developing cost-sharing programs.

Conclusion

Fleeting areas are insufficient to meet present industry needs and future growth.

Identification of potential fleeting areas is necessary in selecting the most desirable site to meet industry needs and environmental concerns. The Upper Mississippi River Basin Commission Level B Study Report and Environmental Impact Statement concerning commercial river navigation in the St. Paul/Minneapolis area supports the needs of navigation in that area.

Recommendation

13. Physical inventories to identify potential fleeting areas for meeting present shortages and future development should have industry representation.

Conclusion

Predesignated closing and opening shipping dates would have an adverse impact on the economy.

Recommendation

14. Predesignated navigation opening and closing dates should not be established.

Conclusion

The suitability models of the Geographic Information System, as currently designed, are not appropriate for identifying areas suitable for barge fleeting or terminals.

Recommendation

15. The Geographic Information System should be refined, expanded or modified and include all recommendations contained in the section on suitability models.

Conclusion

Reflective coatings on barges would have no practical beneficial impact for the recreational boater.

Recommendation

16. State and Federal agencies concerned with boating safety should intensify efforts to educate recreational boaters on rules of the road and lighting requirements applicable to commercial and recreational vessels.

Conclusion

Barge tie-off requirements are very difficult to standardize because of the many different terminal and fleeting area conditions. The scope of this problem in GREAT I is insignificant and does not demand further study. Also, sufficient incentives exist for industry to provide suitable tie-offs.

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ATTACHMENT 1

DESIGNATED BARGE FLEETING AREAS
ON THE UPPER MISSISSIPPI RIVER

Designated barge fleeting areas on the Upper Mississippi River (pools 1-10) with current or pending Corps of Engineers permits

Fleeting area	Location: River mile	Location: Bank	Size(feet)	Capacity (barges)	Permit holder	Towing operator	Barge contents
Minnesota River							
Cargill	12.8	Left and right	2,000 by 100 2,850 by 115	42	Twin City Barge and Towing, St. Paul	Twin City Barge and Towing	Primarily grain and soybean oil; some petroleum products, steel and concrete construction materials, and salt.
McGowan (1)	11.2	Right	875 by 1,960	47	Richard B. McGowan, Minneapolis	Twin City Barge and Towing	Probably grain.
Mississippi River							
Minnesota River mouth	843.5	Right	1,600	16	Twin City Barge and Towing	Twin City Barge and Towing	Sand and gravel.
Minnesota Harbor Service	840.3	Right	883	4	St. Paul Port Authority	Minnesota Harbor Service, St. Paul	
High Bridge	840.2	Left	1,750	22	St. Paul Port Authority	Capitol Barge Service, Inc., St. Paul	Coal and grain.
Robert Street	839.1	Right	1,100	11	St. Paul Port Authority	Capitol Barge Service, Inc.	
State Street	838.9	Right	1,316	24	St. Paul Port Authority	Twin City Barge and Towing	
Farmland (2)	838.6	Right	600	1	St. Paul Port Authority	Farmland Industries, Inc.	Dry fertilizers.
Gustafson Oil	838.5	Right	200	1	St. Paul Port Authority	Farmland Industries, Inc.	Gas and oils.
Lower Twin City (3)	838.0	Right	2,482	24	St. Paul Port Authority	Twin City Barge and Towing	
Mid-American	838.5	Right	2,130	30	St. Paul Port Authority	Mid-American Lines, Inc., St. Paul	
North Point	837	Right	4,330	60	St. Paul Port Authority	Minnesota Harbor Service	

Designated barge fleeting areas on the Upper Mississippi River (pools 1-10) with current or pending Corps of Engineers permits (Cont)

Fleeting area	Location: River mile	Location: Bank	Size (feet)	Capacity (barges)	Permit holder	Towing operator	Barge contents
Hanger	837.5	Left	1,000		St. Paul Port Authority	Capitol Barge Service, Inc.	
Southport Slip (4)	836.0	Right	1,400	39	St. Paul Port Authority	Aiple Towing Co., Stillwater	
Airport	836.5	Right	4,135	24	St. Paul Port Authority	American Commercial Barge Lines, Rosemont	
Dakota (5)	836.3	Right	1,600		St. Paul Port Authority		
Valley Line	835.0	Right	2,100		St. Paul Port Authority	Valley Line Co., Minneapolis	
North Star and Red Rock	833.6	Right		90	St. Paul Port Authority	Twin City Barge and Towing	Coal, grain, petroleum products, salt, fertilizer, and cement.
Pigs Eye Lake	833.2	Right	3,600	54	St. Paul Port Authority		Coal, grain, petroleum products, salt, fertilizer, and cement.
	833.2	Left (6)	640		St. Paul Port Authority	Twin City Barge and Towing	Coal, grain, petroleum products.
Prescott Island	810.7	Right		57	Northern States Power Co., Minneapolis	Twin City Barge and Towing	Coal to Allen S. King Power Plant on the St. Croix River.
Redwing (7)	788.4	Left		15			
Alama	751.4	Right					Coal.
Winona (Crooked Slough) (8)	727.0	Right		15	Winona Port Authority		

Designated barge fleeting areas on the Upper Mississippi River (pools 1-10) with current or pending Corps of Engineers permits (Cont)

Fleeting area	Location: River mile	Location: Bank	Size (feet)	Capacity (barges)	Permit holder	Towing operator	Barge contents
La Crosse (Hintgen Island)(9)	696.0	Right		10-20		Sam Jones, Harbor Services, La Crosse	
Genoa	678.5	Left					Coal.
Lansing Inter-State Power	659	Right	1.25 miles			Wey Miller Marine, Inc.	Coal.
Hunters Lake	727.3	Right		30+	Winona Port Authority		Grain.

(1) Proposed fleeting area.
(2) Authorized in 1944.
(3) Will be abandoned when proposed North Port fleeting area is developed.
(4) Future development of navigation facilities would reduce fleeting capacity.
(5) Proposed application by St. Paul Port Authority.
(6) Fleeting will be eliminated with development of this site.
(7) Permit application on file for 27-barge fleeting area by Central Soya Co., Ft. Wayne, Indiana.
(8) Permit application on file by Froning for 33 additional barge fleeting spaces.
(9) 48-barge expansion proposed by James Julian, Bradyville, Tennessee.

ATTACHMENT 2

FLEETING SITE HISTORY -
TWIN CITIES HARBOR

Fleeting site history - Twin Cities Harbor
23 February 1977

Site	Footage 1959	Footage 1976
Port Cargill		
Left bank	2,200	2,200
Right bank	0	2,850
Minnesota River mouth		
Pike Island	1,000	0
Right bank	1,600	1,600
Left bank	2,000	0
Lexington Avenue	1,000	0
Northern States Power Peninsula	1,000	0
Minnesota Harbor Service	900	900
High Bridge	0	1,750
Robert Street	1,100	1,100
State Street	1,300	0
Mid-America	0	2,130
North Port	0	4,330
Upper and lower Twin City	2,400	2,400
Hanger	0	1,000
Pigs Eye Upper	1,000	0
South Pacific	1,600	0
Airport	6,000	4,153
South port	1,400	1,400
Valley Line		
Left bank	2,100	2,100
Right bank	800	800
Packing house	1,200	2,600
Mid-America	1,200	0
North Star	0	2,400
Red Rock	0	1,800
Pigs Eye Lake		
Right bank	0	3,600
Left bank	0	1,500
Total	29,800	40,613

ATTACHMENT 3

GREAT I AREA BEND WIDTHS

GREAT I area bend widths

Bend location	River mile	Bend width (feet) ~~(1)~~				
		Normal				
		Before dredging	After dredging	Last sounding	Maximum potential	Suggested
Below locks and dam 1	846.3 - 846.7			150	200	150
Fort Snelling	845.7 - 846.3			200	250	200
Lower mouth - Minnesota River	843.3 - 844.3			250	300	300
Lilydale, Minnesota	841.7 - 842.4			300	350	300
Below Omaha Railroad Bridge	840.7 - 841.4			250	250	250
Above Beltline Railroad Bridge	835.7 - 836.3			400	500	400
Armour	832.9 - 833.6			400	400	400
Grey Cloud Slough	827.3 - 828.0	250	400	500	500	450
Pine Bend head light	825.0 - 826.2	200	400	350	400	400
Pine Bend foot light	823.3 - 824.3	250	375	350	375	375
Grey Cloud landing	822.3 - 823.3	250	400	400	400	400
Boulanger Bend	820.3 - 821.5	250	450	500	500	500
Boulanger Bend lower light	818.4 - 820.3	250	450	450	500	400
Nininger, Minnesota	817.8 - 818.4	250	400	400	500	400
Upper approach - locks and dam 2	815.6 - 816.9			500	600	500
Hastings highway bridge	813.8 - 814.2			450	450	450
Point Douglas, Wisconsin	812.4 - 813.0	250	400	400	500	400
Prescott, Wisconsin	810.0 - 810.7	300	450	500	600	450
Truesdale Slough	808.2 - 808.8	200	350	350	400	400
Four Mile Island	807.2 - 807.8	350	450	500	500	500
Below Wind Creek	800.0 - 800.7	300	500	500	500	450
Below Diamond Bluff	798.7 - 799.5	250	400	400	500	400
Upper approach - locks and dam 3	797.0 - 798.4	300	600	600	650	600
Trenton, Wisconsin	794.0 - 794.5	200	600	600	650	600
Above Red Wing highway bridge	790.5 - 792.0	300	500	350-450	400-600	500
Below Red Wing highway bridge	789.4 - 790.3	200	500	500	600	500

GREAT I area bend widths

Bend location	River mile	Bend width (feet)[1]				
		Normal				
		Before dredging	After dredging	Last sounding	Maximum potential	Suggested
Goose Bay	787.5 - 788.6	200	350	350	400	350
Head of Lake Pepin	785.2 - 785.6	300	450	450	550	500
Reads Landing	762.4 - 763.3	100	450	500	600	500
Below Reads Landing	761.5 - 762.5	300	450	550	600	500
Crats Island	758.0 - 759.5	100	500	450	600	450
Beef Slough	753.7 - 754.6	200	400	400	450	400
Alma lower light	751.0 - 752.1			450	450	450
Upper mouth - Zumbro River	794.4 - 751.0			500	550	500
Mule Bend	747.8 - 748.8	200	450	500	600	500
West Newton	747.0 - 747.8	250	450	400	600	450
Above Teepeeota Point	757.2 - 757.8	350	500	500	550	500
Lower Zumbro	744.9 - 745.4	350	500	500	650	500
Below West Newton	746.4 - 746.9	300	500	450	650	450
Summerfield Island	742.8 - 743.6	150	400	400	500	400
Minneiska, Minnesota	742.0 - 743.0			500	600	500
Mount Vernon light	740.3 - 741.3	200	500	500	500	500
Richtman light	739.3 - 740.3			550	600	550
Upper approach - locks and dam 5	738.1 - 739.0			500	500	500
Island 58	734.0 - 735.0	200	500	500	600	500
Fountain City	732.7 - 733.5	250	400	400	500	400
Head of Betsy Slough	731.7 - 732.3	250	500	500	600	500
Betsy Slough Bend	731.0 - 731.7	250	450	450	500	500
Wilds Bend	729.5 - 731.0	250	450	500	500	450
Island 71	726.0 - 726.7	300	450	450	500	450
Gravel Point	721.6 - 722.4	300	500	600	600	500
Blacksmith Slough	718.0 - 719.0			500	700	550

GREAT I area bend widths (cont)

Bend location	River mile	Bend width (feet)[1] Normal Before dredging	After dredging	Last sounding	Maximum potential	Suggested
Lamoille, Minnesota	715.6 - 716.6			500	600	500
Head of Richmond Island	712.6 - 713.4	250	450	400	600	450
Queens Bluff	711.0 - 712.0	200	500	500	600	500
Winters Landing	708.0 - 709.0	200	500	300	600	400
Dakota, Minnesota	706.0 - 707.4	150	400	400	500	400
Black River	698.0 - 698.7			600	600	600
Broken Arrow	695.8 - 696.8	300	500	450	600	450
Sand Slough	694.4 - 695.2	300	600	500	700	500
Two Mile Island	691.8 - 692.2			500	800	500
Above Brownsville	690.2 - 691.0	100	400	500	650	400
Brownsville	689.7 - 690.2	100	500	450	600	400
Head of Raft Channel	687.5 - 688.4	200	400	450	500	400
Below head of Raft Channel	686.5 - 687.5	250	400	350	500	400
Deadmans Slough	685.5 - 686.5			400	500	400
Warners Landing	683.0 - 683.6			400	450	400
Island 126	677.2 - 678.2	250	500	450	600	450
Twin Island	676.0 - 677.3	150	400	500	600	400
Bad Axe Bend	674.0 - 675.0	300	600	450	600	450
Head of Battle Island	670.7 - 671.5	300	450	500	500	450
Battle Island	669.8 - 670.7			500	600	500
Lansing upper light	663.8 - 664.4	200	600	500	800	500
Above Lansing bridge	663.4 - 663.8	450	550	450		
Below Lansing	660.3 - 661.0	300	600	450	700	450
Heytmans Crossing	654.5 - 655.5			500	500	500
Crooked Slough foot light	651.6 - 652.4			500	500	500
Gordons Bay	645.4 - 646.1	350	600	400	700	450
Mississippi Gardens	642.5 - 643.5	250	550	500	800	500

GREAT 1 area bend widths (cont)

Bend location	River mile	Bend width (feet)[1]: Normal: Before dredging	Normal: After dredging	Last sounding	Maximum potential	Suggested
Johnsonport	640.6 - 641.8			500	600	500
Wyalusing Bend	628.6 - 629.3	300	600	600	700	500
Wyalusing	627.2 - 628.0	300	600	600	1,000	500
Catfish Slough	625.7 - 626.6			700	800	500
Clayton, Iowa	624.7 - 625.7			750	900	500
French Island	619.8 - 620.6			500	800	500
McMillian Island	617.0 - 619.0	200	500	500	500	500
Ferry Slough	615.6 - 616.3	300	600	600	600	450
Upper approach - locks and dam 10	615.1 - 615.6			600	600	600

(1) Definitions

Normal width before dredging - continuous channel width at low control pool before the beginning of maintenance dredging with a depth of 10.5 feet or greater. In many instances, maintenance dredging is done before pool levels reach low control pool and the width noted is not encountered in actual navigation.

Normal width after dredging - When dredging is completed, the navigation buoys are moved to the edge of the dredge cut.

Width at last sounding - width of channel noted by navigation aids as of most recent survey. Adjustment of the buoys may have occurred since that time.

Maximum potential width - maximum theoretical dredging width which could be accomplished without wing dam modification or without changing the existing shoreline.

NOTE: The information was obtained from a survey by the GREAT I Commercial Transportation Work Group of rivermen qualified in the area of concern.

ATTACHMENT 4

GUIDELINES FOR CHANNEL MAINTENANCE

DREDGING AND DISPOSAL

GUIDELINES FOR CHANNEL MAINTENANCE DREDGING AND DISPOSAL

BACKGROUND AND DISCUSSION

In accordance with the congressional mandate to maintain the authorized Mississippi, Minnesota, and St. Croix River 9-Foot Channel Projects, the St. Paul District annually dredges:

1. The Mississippi River between Guttenberg, Iowa, and Minneapolis, Minnesota (Cairo mile 614.0-857.6).

2. The Minnesota River between the confluence with the Mississippi River and Savage, Minnesota (mile 0.0-14.7).

3. The St. Croix River between the confluence with the Mississippi River and Stillwater, Minnesota (mile 0.0-24.5).

The authorized channel dimensions for these maintenance activities are described in the 1930, 1935, and 1958 River and Harbor Acts.

As specified in this enabling legislation, the authorization is for a channel depth of 9 feet at low water with widths suitable for long-haul common carrier service. Approximately 36 locations have required annual dredging. The average annual volume of material being removed from the navigation channel has been approximately 1.4 million cubic yards. Dredging was normally accomplished to 9 feet plus an additional 4 feet of "over depth" for a total of 13 feet. The purpose of the "over-depth dredging" was to insure, in spite of sudden and/or gradual sedimentation and shoaling, that a minimum "control" depth of 9 feet could be maintained. The rationale for the 4-foot over depth was twofold. First, past experience had shown that the navigation channel might close within days after reaching a depth of 10 feet, the change being caused primarily by subsequent shoaling and/or bottom effect of motor vessels or barges. An additional 1-foot "safety factor" was added so that a total overdepth of 2 feet was provided to account for channel stability. Second, an additional 2 feet of overdepth was provided to compensate for subsequent shoaling that might occur prior to response by government or contract dredging facilities to assure the integrity of the channel and to maximize cost effectiveness.

For many years these historical practices provided a dependable channel which satisfied the transportation demands of the region. During the late 60's and early 70's, increasing environmental awareness resulted in pressure on the Corps of Engineers to change its channel maintenance procedures. As a result, the Corps changed many of its dredging and disposal practices; preliminary indications are that some significant environmental improvements have been made. However, there are also indications that the resulting navigation channel is unacceptably less dependable and more costly.

Many of the environmental pressures were focused through the GREAT program which was authorized by the Water Resources Development Act of 1976. In responding to these pressures, and as much as possible within the framework of the GREAT program, the St. Paul District became involved in an increased number of pilot studies and trial programs whereby it modified its historic dredging and disposal procedures.

For example, during the 1977 dredging season, dredging was accomplished when the channel depth reduced to 10.5 feet or less below minimum water levels instead of 11 feet. Also, dredging depths were reduced at 65 percent of the maintenance sites on the Mississippi River as follows:

Depth of dredging (feet)	Sites	Remarks
13	3	Main channel
12	6	Main channel
11	5	Main channel
6	2	Lock and harbor maintenance

While the modified practices significantly reduced the amount of dredged material for 1977, it is not yet clear whether the additional dredging was eliminated or simply deferred. This matter is particularly uncertain because the extremely low 1977 spring flow conditions are thought to have contributed strongly to reduced shoaling and, hence, unusually low 1977 dredging requirements. Additional time, experience, and information are necessary before these matters are adequately understood; however, they do provide clear indication that "reducing dredging volume" is not a singularly beneficial, risk-free objective.

Various parties within and outside of GREAT I have placed major emphasis on the use of "total annual dredging volumes" as a measure for judging the merit of a proposed change to channel maintenance practices. However, other measures should be considered. From a commercial navigation point of view, at least four measures are of concern.

1. <u>Increased Risk of Grounding</u>

Increased grounding could lead to many negative effects including, but not limited to:

a. Increased transportation costs resulting from delays caused by channel closure and/or physical damage to tows.

b. Increased pollution resulting from physical damage to tows.

c. Reduced reliability of the waterway system to satisfy the transportation demands of the public.

2. <u>Increased Transit Time and Fuel Consumption</u>

Transit time and fuel consumption increase as a result of slower navigation (especially around bends) and increased resistance caused by a smaller, more restrictive channel. Quantitative data to describe the magnitude of these affected areas follows: (1)

(1) Speed that can be maintained in given channel by 3-barge wide, 2-barge long tow, 8.5-foot draft, 1,000 tow rope horsepower.

Channel width (feet)	Channel depths		
	11 feet	13 feet	18 feet
125	3.7 knots	4.10 knots	5.02 knots
225	4.55 knots	5.30 knots	6.38 knots
300	4.95 knots	5.67 knots	6.64 knots

It can be readily seen that a given channel width or depth has a direct effect on vessel performance. If the effect of a 50-foot channel width reduction resulted in a 0.4-knot speed loss it would be considered inconsequential by some. The cumulative effect, however, if applied uniformly to the 1,700-mile trip from St. Paul to New Orleans, would result in over 5 hours being added to the vessel's trip. Multiplied by the number of barge trips, the effect would be substantial. The same is true of channel depth. Vessel performance relates not only to increased shipping costs, but to energy consumption, effects on the environment, maneuverability and safety. For example, to travel 4.5 knots in a 125-foot channel requires almost double the horsepower (1,900 vs 1,000 horsepower) for the same speed in a 225-foot channel.

3. Reduced Cargo Capacity

Reduced cargo capacity may result from a smaller, less dependable channel. Action to reduce the minimum "control" depth below 9 feet, or even to reduce confidence in the availability of a minimum 9-foot channel, could result in higher transportation cost for goods in and out of the Upper Midwest.

4. Cost of Channel

The fourth concern relates to the cost to the taxpayer or towing industry for channel operation, maintenance and new facilities.

RECOMMENDATIONS

The following recommendations were developed in light of the matters presented above. Additionally, they reflect the work group's experience in the GREAT I development of annual dredging and disposal recommendations to the Corps and in subsequent activities related to the on-site inspection team meetings. The recommendations attempt to reflect a moderate approach which is balanced and equitable and would protect and enhance the environmental and economic well-being of the GREAT I area.

1. The forms at the end of this attachment should be used to help evaluate and document dredging and disposal operations.

2. Recommendations for dredging depths should be obtained annually from a fluvial hydrologist, qualified in the river areas of concern. The hydrologist should use as a guideline the policy that, throughout the period from one expected dredging to the next, the channel depth should not fall below 9 feet at low water.

3. The work group recommends that bend widths be determined by mathematical formulas such as those contained in Corps of Engineers Technical Letter 1110-2-225 dated 1 July 1977. Changes in bend widths or channel alignments should not be instituted without first obtaining input from licensed tow boat operators and the towing industry; for example, the Upper Mississippi Waterways Association and American Waterways Operators. Their knowledge of the river and its many operational characteristics cannot be ignored and is better than any intuitive decisions made by persons not totally familiar with barge and towing technology.

4. In considering alternative dredging widths and depths and disposal sites, the following should be considered:

a. Will the channel characteristics or the disposal site physically impede navigation?

b. Will the channel characteristics or the disposal site infringe on existing or proposed barge fleeting or terminal areas?

c. Will the channel characteristics or the disposal site change the river's flow characteristics and impede navigation, undermine structural foundations (for example, create scour conditions around piers or bridges), or impair the placement and/or station keeping of aids to navigation?

d. Will the channel characteristics or the disposal site pose a hazard to the safety of life and property not covered by the above three items?

e. Will the proposed dredging and disposal (channel maintenance) practices involve costs (reflected to some common base year) which would be greater than would have existed historically? For the dredging aspect, special attention should be given to actual dredging costs and towing industry costs that would result from increased transit time and energy, or reduced cargo such as might be necessitated by reduced depth dredging and/or narrower bend or channel widths. For the disposal aspect, special attention should be given to land use acquisition, material transportation, and site preparation/maintenance costs.

5. Channel maintenance practices should not be changed if the risk of grounding would increase. If the risk of grounding will increase, but the change is still warranted, before implementation the proposed change and its expected effects should be clearly described and discussed through some public medium; for example, the Corps annual navigation season public notice of channel maintenance dredging and/or the Corps notifications of on-site inspection team meetings. The effects discussed should include but not necessarily be limited to:

a. Increased transportation costs resulting from delays caused by channel closure and/or physical damage to tows.

b. Increased pollution resulting from physical damage to tows.

c. Increased personnel hazards resulting from actual grounding and/or rescue or recovery efforts.

d. Reduced reliability of the waterway system to satisfy the transportation demands of the public.

6. Channel maintenance practices should not be changed, if transit time and energy used increase or cargo capacity is reduced. If a proposed change will increase the transit time and energy or reduce cargo capacity, but the change is still warranted, before implementation the proposed change and its expected effects should be clearly described and discussed through some public medium; for example, Corps annual navigation season public notice of channel maintenance dredging and/or the Corps notification of on-site inspection team meetings.

7. The cost of all dredging and disposal alternatives should be determined and justification provided for not selecting the least costly method.

Sample form
(To be used in evaluating and documenting channel maintenance dredging and disposal operations in the St. Paul District)

I. Predredging/disposal evaluation:

A. Dredging:

1) Navigation point of view

a. Does the general area of the proposed dredge cut have a history of sudden, rapid reduction in channel depth? ______________Yes ______________No

If yes, explain.

b. If the proposed dredging is accomplished, how will the resulting channel depth differ from the depth after the most recent dredging?
(The new depth will be)
________________Shallower ____________Same Depth
________________Deeper

c. Have any groundings by commercial river transportation at the proposed dredge cut been reported to the Corps of Engineers since the most recent dredging?
_________________Yes _________________No

If yes, describe all such reports. In particular, for each report, attempt to provide the following information:

Date of report		_________________
Date of grounding		_________________
Reported by (person/company)		_________________
Damage (general description and/or cost)		_________________
Time vessel delayed (hours)		_________________
Soundings taken after incident		_________________
If yes,	Date	_________________
	Depth	_________________
Draft of vessel(s)		_________________

Comments on actions taken by Corps after grounding:

d. If the proposed channel depth after the proposed dredging will be shallower or the same as the depth after the most recent dredging, and if groundings (because of channel depths less than 9 feet) have occurred at the proposed dredge cut since the most recent dredging, what is the Corps justification for not increasing the depth to reduce the risk of additional groundings?

e. Have any complaints or incidents been reported to the Corps since the most recent dredging such that the channel/bend width or configuration is or may be inadequate for proper navigation? ________________Yes ________________No

If yes, describe all such reports or incidents. In particular, for each report, attempt to provide the following:

Date of report ________________
Reported by (person/company) ________________
Nature of complaint/incident ________________

Comments on actions taken by Corps in response to complaint/incident:

f. Is the proposed dredge cut located on a bend?
________________Yes ________________No

If yes, did the Corps survey licensed tow operators who are experienced in the area of concern to determine whether the existing and the proposed bend widths are adequate for proper navigation? ____________________Yes ______________No
________________Not Applicable

If yes, name the operators surveyed and describe the results of the survey.

If no, what is the Corps justification for not conducting the survey?

g. If the proposed dredging is accomplished, will the resulting navigation channel infringe on existing or proposed barge fleeting areas? ______________Yes ______________No

If yes, briefly describe the infringement and the Corps reasons such infringement is necessary or desirable.

h. If the proposed dredging is accomplished, will the resulting channel characteristics change the river's flow characteristics and impede navigation, undermine structural foundations, or impair the placement and/or station keeping of aids to navigation?
________________Yes ________________No

If yes, briefly explain.

i. Comparing the channel which existed after the most recent dredging with the channel that would result if the proposed dredging is accomplished, will the hazards to the safety of life and property be changed, for example, increased risk of grounding or collision?
____________________Increased hazards ______________No change
____________________Decreased hazards

Briefly explain:

2) Economic point of view

a. If the proposed dredging is accomplished, will the resulting channel characteristics involve navigation-related costs that are greater than would have existed prior to GREAT. (Note: For the purposes of this item navigation costs should be considered to be those caused by increased tow energy usage, increased tow transit time, or reduced tow cargo such as might result from reduced depths and/or reduced channel or bend widths.)

If yes, briefly explain and quantify if possible.

b. (See item II-C where dredging and disposal costs to the Corps are considered together.)

B. Disposal

1) Navigation point of view

a. Will the proposed disposal site physically impede navigation such as by obstructing necessary tow maneuvering space or visibility? ________________ Yes ______________ No

If yes, briefly explain.

b. Will the proposed disposal site change the river's flow characteristics and impede navigation, undermine structural foundations, or impair the placement and/or station keeping of aids to navigation?

________________ Yes ________________ No

If yes, briefly explain.

c. Will the proposed disposal site pose a navigation-related hazard to the safety of life and property not covered by the above items? ________________ Yes ________________ No

If yes, briefly explain.

2) Economic point of view (See item II-c where dredging and disposal costs to the Corps are considered together.)

C. Corps of Engineers costs -

1) Dredging costs-Will the proposed dredging operation involve Corps-related costs that are greater than would have existed prior to GREAT I? ___________________ Yes ________________ No

If yes, explain. Itemize and quantify if possible.

2) Disposal costs-Will the proposed disposal operation involve Corps-related costs that are greater than would have existed prior to GREAT I? (Note: For the purpose of this item, Corps-related costs should be considered those for land use acquisition, dredged material transportation, and site preparation/maintenance.)

_____________________ Yes __________________ No

If yes, explain. Itemize and quantify if possible.

3) Estimated total Corps costs of dredging disposal operation (dollars) ____________________________

4) Estimated total Corps cost per cubic yard (dollars)

____

D. Recommendations for changes to proposed dredging operation(include justification/rationale for each recommendation):

E. Recommendations for changes to proposed disposal operation (include justification/rationale for each recommendation):

F. Miscellaneous comments:

II. Postdredging/disposal evaluation:

A. Dredging-Were the recommendations of I-D incorporated?
________________________Yes ________________________No

If no, explain.

B. Disposal-Were the recommendations of I-E incorporated?
________________________Yes ________________________No

If no, explain.

C. Total Corps cost of dredging/disposal operation (dollars) ______________

D. Total Corps cost per cubic yard (dollars) ____________________

E. Recommended changes to evaluation form:

F. Miscellaneous comments:

ATTACHMENT 5

PACKER RIVER TERMINAL

CASE HISTORY

Mailing Address
P O Bo
St Paul
Telephone

Terminal

January 9, 1979

Mr. Erv A. Timm
Executive Direc or
Upper Mississippi Waterway Association
305 Osborn Building
Saint Paul, Minnesota 55102

Dear Erv:

This letter is in response to your December 13, 1978 letter to me, requesting a summary of the regulatory bureaucracy encountered by Packer River Terminal in seeking appropriate permits to initiate development of its terminal facilities in South St. Paul, Minnesota. The following will represent a basic skeleton response to your requests. I am sure that Bill Newstrand, of MnDOT will understand what most of the implications are in such an outline.

The idea for Packer River Terminal originated back in the late 1960s. The location was in the northerly end of the City of South Saint Paul, along the Mississippi River front. For various reasons that project never proceeded, however, in 1973, Twin City Barge and Towing Company, in conjunction with others, initiated the terminal project with the present site as their objective. The present site is the location of facilities originally abandoned by the Boise Cascade Corporation in the middle 1960s (I believe 1967). The abandonment of the facility, as a terminal for paper products transshipment, followed original construction almost immediately, for economic reasons, as we understand. Boise's original intention when the property was developed, was to construct a barge slip to the river and records in the St. Paul District Offices of the Corps of Engineers support this statement. Since 1967, the property was vacant, deteriorating, utilized very little, and had become a blighting influence on the neighboring area.

I can speak with some authority in this regard, since from early 1970, until early January, 1976, I was City Engineer, then Director of Community Development for the City of South St. Paul. In that capacity, I can speak to the City's interests and concerns with respect to ultimate development and reutilization of the property, and its affect on the general area. A reader of the following outline of our experiences with the regulatory process should recognize that I was associated with the City of South Saint Paul through the year 1975, and from January 1976 assumed my current position as

President of Packer River Terminal.

The dual exposure, on my part, noted above allowed me the opportunity to develop an insight to not only the terminal project, but also the folly of the regulatory process, as it affected Packer's development objectives.

Going back, then, to my earlier comment, the formal conception of Packer River Terminal, occurred in 1973, when officials of Twin City Barge and Towing Company entered into verbal understandings with Boise Cascade Corporation to initiate the development process for the Packer site. The understanding between the parties was that at such time as approval of appropriate permits was eminent, a lease agreement would be executed. The following, then, represents a historical outline of the occurrences from that point, in late 1973, until a Section 404 Permit, pursuant to the requirements of the Federal Water Pollution Control Act Amendments, was approved by the St. Paul District of the Corps of Engineers. The historical summary follows:

<u>THE YEAR 1974</u>:

FEBRUARY: Following understandings with the Boise Cascade Corporation, Twin City Barge and Towing Company officials (TCB) initiated communications with the City of South Saint Paul. Those communications included a meeting with the City Council, a meeting with the City Planning Commission, and meetings with officials of the City's Environmental Commission and its Economic Development Authority. These bodies endorsed the terminal development concept and encouraged TCB officials to proceed with their development plans.

MARCH: TCB officials provided information on the proposed terminal development to the Environmental Protection Agency Offices in Minneapolis, with directions that if any EPA concerns arose that they contact TCB officials as soon as possible.

JUNE: A Section 10 application pursuant to the River and Harbors Act was submitted to the Corps of Engineers and other appropriate agencies involved in the review of such an application. In essence, the Section 10 application explained the project, indicated the type of commodities to be handled, and proposed to construct the barge slip.

SEPTEMBER: In September, after almost 3 months of review by Corps of Engineers officials, the Corps of Engineers published notice of Packer's Section 10 application.

Following publication of a Public Notice of Packer's Section 10 application, there was a period of time allowed for comments by intereste⁻ parties. The machinations that occurred in this regard are another subject altogether, and there is no point in discussing some of that here. Suffice to say, with some small amount of confusion and several meetings back and forth between different agencies and groups, things muddled on.

THE YEAR 1975:

JANUARY: Because of several questions raised by interested parties, the Environmental Quality Council deemed fit to request review of an Environmental Assessment for the Packer Project. Such an assessment was prepared, filed with the EQC during January of 1975, and their staff initiated their review.

MARCH: After some two plus months of review, the EQC, for all practical purposes, approved the Packer Project by indicating that no EIS would be required. The EQC indicated that the project was a local matter, and that other permit processees of the State and Federal Governments were adequate to address issues raised in the assessment.

APRIL: The Packer Project received a water quality clearance from the Minnesota Pollution Control Agency with respect to Section 401 of the F. W. P. C. A. Amendments. In addition, Minnesota Department of Natural Resources (DNR) issued their permit, with conditions, for construction of the barge slip.

MAY: During the early months of 1975, representatives of the Fish and Wildlife Service expressed concern with respect to the Packer Project. These concerns had to do with the location of the barge slip, and impact on adjacent wetlands. Therefore, in early May, representatives from Packer, Corps of Engineers, Fish and Wildlife Service and the City, among others, met in an attempt to resolve these issues and concerns. A proposal was set forth by myself (at this point, still working for the City of South St. Paul) wherein the barge slip would be constructed basically as proposed by Packer, with the suggestion that adjacent lands owned by the American Hoist and Derrick Company be acquired by Packer, and a portion set aside for public open space. It was the understanding of all parties at this meeting that Packer's Section 10 Permit could go forward if such an understanding were achievable. Packer officials then met with representatives of American Hoist, and obtained their agreement to make the properties available for sale, and so notified all parties present at the original meeting in early May. In addition, based on the understanding, Packer submitted an amended Section 10 application, to reflect the acquisition of some 50 additional acres of land, with the understanding that slightly over half of that land would be set aside for public dedication.

On the basis of the above, the Fish and Wildlife Service saw fit to issue a clearance letter for the project, with the stipulation that the above noted understanding was the basis for that clearance.

During this same month, the Minnesota Pollution Control Agency issued their own Permit for the Packer Project.

During the period from January through May, the Corps of Engineers continued to keep the Chicago offices of EPA informed as to the status of the Packer Project, to include items noted above with respect to resolution of the Fish and Wildlife concerns. However, EPA in late may, directed an objection to the Corps of Engineers. The EPA objection was with respect to wetlands, and their objection indicated that their concern could be alleviated if wetlands associated with the Fish and Wildlife understandings to include wetlands on that portion of Packer's property and the "not to be dedicated" portions of the American Hoist property yet to be purchased, were protected.

I should note here that the EPA objection to filling wetlands went back to a Court case which came about in early 1975 (March, I believe) wherein the Corps of Engineers and EPA had been directed by a federal judge, in a court case, to exercise their authority pursuant to Section 404, of the Federal Water Pollution Control Act Amendments. The exercise of which authority would occur through the publication and enforcement of regulations related to wetland issues. Therefore, the delays and foot-dragging which occurred during the late months of 1974 and early months of 1975 had placed Packer in the position wherein it was required to apply for a second permit to accomplish the ultimate development of its facilities, rather than being able to proceed with the basic terminal project upon receipt of a Section 10 Permit. This was not a major concern to Packer at this point in time, however, since it appeared that the 404 Permit would ultimately be issued since the concerned parties had already reached a basic understanding in early May with respect to the lands in question.

JULY: In July, the Corps of Engineers published its regulations with respect to a 404 Permit application. At the same time, the Minnesota Historical Society issued a clearance for the Packer Project. Shortly afterward, the Corps of Engineers issued the Section 10 Permit for construction of the barge slip, with the condition that the wetland properties, noted earlier, not be developed until a 404 Permit was obtained. A 404 Permit could not be applied for however, since EPA had not yet published its own 404 regulations.

SEPTEMBER: EPA finally published its 404 regulations during this month.

OCTOBER: Shortly after the publication of EPA's regulations, on October 16, 1975, to be exact, Packer submitted its Section 404 Permit Application, which was basically for the authorization to utilize wetland areas restricted by the Section 10 Permit, but which had been indicated as acceptable for filling in the earlier litigation process with the Corps of Engineers and the Fish and Wildlife Service, in May of 1975.

NOVEMBER: The City of South Saint Paul recommended approval of the 404 Application, by the Corps of Engineers.

DECEMBER: The Corps of Engineers published Public Notice of Packer's 404 Application, requesting comment by interested groups and agencies, a required practice in the regulation of the Corps and EPA.

THE YEAR 1976:

JANUARY: After the period of Public Notice noted in the Corps request for comments to Packer's Permit Application, EPA (in Chicago) filed a letter of objection to the terminal project.

FEBRUARY: The Minnesota Pollution Control Agency cleared the 404 Project. The Fish and Wildlife Service cleared the 404 Project, noting the earlier understanding in May of 1975. The Minnesota Historical Society issued a clearance letter. The Minnesota Department of Natural Resources issued a clearance letter, noting the earlier agreement in May of 1975.

In mid-February, upon recommendation by the St. Paul District Corps of Engineers, I personally met with representatives of EPA in Chicago. I should note here that I assumed my position with Packer River Terminal in January of this year, and had immediately undertaken to understand EPA's objections to the project, and to attempt to resolve those objections. At my meeting with EPA representatives in Chicago, it was indicated to me that the 404 Permit, per se, was not objectionable by EPA, however they were concerned that their legal department did not feel they could be party to a mitigation proceeding such as was undertaken in May of 1975, and expanded by me in my meeting with them. When I left the meeting with the EPA officials, however, I was led to understand that they would discuss this matter with their legal staff and, barring a major objection, would attempt to issue clearance for the project. (Ultimately there was no such clearance forthcoming).

MARCH: Lacking EPA concurrence, or clearance of the project, Corps officials indicated that they might require the preparation of an Environmental Impact Statement (EIS) for the entire terminal project. On the face of it, this was a ridiculous requirement since the basic terminal project had already been approved via the issuance of the Section 10 Permit, and the 404 Permit did not appear to imply negative impacts of any significant nature. It also became obvious at this point in time, that certain representatives of the District office of the Corps of Engineers were no longer prepared to honor the original understandings of May, 1975.

MAY: Packer was required, based on original negotiations with the Boise Cascade Corporation, to exercise its option to purchase their properties. While it appeared in May of 1975 and in the months leading up to March of 1976, that no major problems would be encountered with the 404 Permit, it was too late to turn back and Packer (with much consternation) was compelled to exercise its purchase option with Boise, or risk loss of the availability of the terminal site.

During the ensuing months, there were several meetings with Corps of Engineers and EPA officials, including representatives of the Co[illegible] and EPA offices in Chicago.

OCTOBER: Finally, in late October, the Corps of Engineers indicated it would waive the requirement for an EIS if Packer would address specific concerns raised by EPA such that EPA could release their objections to the project.

NOVEMBER: In an effort to alleviate the concerns of EPA, therefore, Packer retained a private consultant to meet with EPA officials in Chicago, to describe their concerns and to address those concerns in as much detail as possible.

THE YEAR 1977:

JANUARY: As noted earlier, in February, 1976, the Minnesota Department of Natural Resources issued a letter of clearance for the 404 Project. It became quite clear that no major changes would be required by DNR with respect to the Section 10 Permit or with respect to Section 404 expansion, and they issued their formal permit for the 404 Project during this month.

In addition, Packer's consultant responded with a report directed to the issues raised in its November, 1976 meeting with the EPA officials in Chicago. In anticipation of problems with both the Corps and EPA, Packer had separately undertaken to prepare an expanded Environmental Assessment for its terminal project, and incorporated its consultants report with respect to issues raised by EPA, as noted earlier. Packer undertook such an expanded assessment based on what appeared now, to be a history of delays, and subterfuge, by individuals at EPA and the Corps who appeared to be carrying some special vendetta with respect to the development. Suffice to say that EPA, in spite of the consultant's report which indicated no significant impacts on the wetland environment, still objected to the project, and conveyed that objection to the Corps. The Corps, therefore, proceeded to call for an EIS, and utilized Packer's expanded Environmental Assessment as the basis for that document.

APRIL: Following several months of confusion (since January), the Corps finally published the EIS in mid-April, requesting public comment and response.

MAY: As before, the City of South Saint Paul endorsed the terminal project. The Minnesota Historical Society issued its clearance. The Metropolitan Council issued a letter of endorsement for the project. The Critical Areas Staff of the Environmental Quality Council issued its endorsement.

JUNE: As expected, EPA again objected to the project and issued its classification as "E U I" - which means Environmentally Unsatisfactory, with the numberal I indicating a catagory wherein EPA suggests that there is enough information available to evaluate and judge the project.

AUGUST: The City of South Saint Paul's Environmental Commission endorsed the project. The Mayor of the City of South Saint Paul sent a separate letter of endorsement for the project.

NOVEMBER: Following expiration of the comment period with respec to the Federal EIS Draft, the Corps of Engineers assemble a Final EIS, and published notice of its availability for review.

DECEMBER: Notice of the availability of the Final EIS was published in the State Register.

With one or two days left, EPA officials in Chicago requested that the Corps of Engineers extend the comment period for the Final EIS. This was an inappropriate procedure on the part of EPA, since their request for the extension of the comment period was made through the Chicago offices of the Corps of Engineers, which was procedurally incorrect, since extensions could not be granted by the St. Paul District Engineer. It was not until some days later that the St. Paul District Engineer was informed of this matter, - - in my conversations with him indicated that he had not delegated authority to anyone, save himself, to extend the comment period on the EIS. Packer objected to EPA's violation of procedure, in correspondence to the District Engineer.

THE YEAR 1978:

JANUARY: It appeared by this time, to ourselves and the District Engineer of the St. Paul District, Corps of Engineers, that EPA was not going to provide the comments which it indicated it would be sending in December of 1977. The District Engineer waited until some time in mid-month and having not received the EPA comments, undertook to make a recommendation to the Division Engineer ` Chicago that the 404 Permit be granted to Packer. During this same period, without the knowledge of the District Engineer, or Packer, EPA directed letters to the President's Council on Environmental Quality (Washington D.C.) and the Chief of Engineers, (Washington D. C.). The letters to both were identical, continued to express an objection by EPA to the Packer Project.

FEBRUARY: The Division Engineer of the Corps, in Chicago, following discussions with EPA representatives in Chicago, noting their continued objection, forwarded the matter to his superiors at the Chief of Engineers offices, in Washington, D. C., with the recommendation that the Section 404 Permit be issued to Packer.

APRIL: Following discussions at the Washington D. C. level, in March and early April, the President's Council on Environmental Quality, for all practical purposes rejected EPA's rational for objection to the Packer Project indicating that the St. Paul District Engineer for the Corps could issue the 404 Permit, subject to expanded information with respect to the availability of alternative sites. The alternative sites issue was raised, as a last gasp, by EPA, likely with the recognition that their previous procedural errors were catching up to them.

Without going into a lot of detail, the EPA had suggested that the Corps of Engineers consider the Municipal Maintenance Shop properties owned by the City of South Saint Paul, properties adjacent to that site, owned by the St. Paul Union Stockyards Company, and properties of the Chicago Rock Island Railroad Company, immediately south of Packer's site.

JUNE: The study of alternative sites mentioned earlier by the Corps was rather detailed. In essence, the City of South Saint Paul rejected the use of its maintenance properties; the Stockyards Company asked for a value which substantially exceeded what appeared to be market values for properties in the area; and the Chicago Rock Island Railroad properties appeared to be unavailable (at least for a goodly length of time) because that railroad is in receivership. In essence, the District Engineer completed his evaluation of alternative sites, set those forth in writing, and notified his superiors and EPA that his evaluation indicated the alternative sites were not reasonable and prudent alternatives, and therefore that it was his intent to proceed with issuance of the 404 Permit.

JULY: On or about July 5, the District Engineer issued, to Packer, the 404 Permit for expansion of its facilities. Within days, the EPA indicated to the Chief of Engineers, (Washington, D.C.) that it had not received proper notice from the Corps of Engineers, of its intent to issue the 404 Permit. EPA objected that this was a violation of proper procedure and understanding between the two agencies, and that further, it intended to proceed with review proceedings whereby it might issue a veto of the 404 Permit, implying that such proceedings were available to it through Section 404 (c) of the Federal Water Pollution Control Act Amendments. On the basis of this objection by EPA, the Chief of Engineers offices notified the District Engineer, Corps of Engineers St. Paul District, to suspend Packer's permit. This was done virtually immediately.

Packer responded with a letter to the St. Paul District Engineer, objecting to his suspension of permit, on the basis of procedural errors and inapplicability of the basis for the suspension.

AUGUST: Shortly thereafter, Packer received a draft of regulations purportedly for purposes of eventual publication relating to EPA's authority under Section 404 (c).

At this point, having its fill of the entire regulatory process, Packer filed a motion, in the United States District Court, for an Order enjoining the Corps and EPA from withholding Packer's 404 Permit. The matter came before the court on August 24, at which attorneys for Packer and for the Corps and EPA presented their arguments before the court. Without going into the detail of the proceedings in court, EPA subsequently withdrew its objection to the issuance, by the Corps, of the 404 Permit, subject to the Corps of Engineers holding additional hearings to consider "new information" which had become available to it, and which was not available during original consideration of the Federal EIS.

The court quickly moved to order the presentation of such "additional information" for its review. On the day on which this "additional information" was to be presented to the court, EPA directed a letter to the Corps of Engineers that its review of this "additional information" indicated that it was not of such nature as to likely alter the Corps original conclusion with respect to the issuance of the permit, and that by way of that letter, EPA was withdrawing its objections to the issuance of Packer's permit. This final action by EPA occurred in early September of 1978.

As the above historical outline indicates, the regulatory procedure consumed a period of time which began in February of 1974, and concluded in September of 1978, a period of some 4½ years. This process represents a significant expense to Packer, and its parent corporation, Twin City Barge and Towing Company. The direct cost of the regulatory process itself was in the neighborhood of some $700,000.00. In addition, had the original Section 10 Permit process been addressed, particularly by the public sector, in a rational and expeditious fashion, that permit would likely have been issued in late 1974 or early 1975, and a 404 Permit never required. The ensuing delays, from early 1975 to late 1978, are fraught with incredible increases in construction costs, and related interest costs for financing. The present value of these increased costs is approximately $7,000,000.00. In view of such circumstances, I think it rather easy to understand our total disgust with the handling of our development. It has been suggested by some agency representatives, either directly to me or to my associates, that we were too hard-nosed toward the end and that we were stubborn or uncooperative. The history of this project suggests the opposite - - and my greatest regret at this point in time was our effort to be cooperative, to be patient, and to try to work within the system. That was a mistake, and continues to be a mistake.

I have a deep respect for many officials and individuals who work for the various groups and agencies with which we came in contact. However, these same agencies are staffed with personnel who are not familiar with the work to which they are assigned, or who have no concern for the fact that interminable delays cost someone money. The ultimate barer of these costs will be the consuming public, to which we all pay our dues. I would hazard a guess that had we anticipated the kinds of delays, and lack of cooperation which were evident in this process, that our companies would have abandoned the Packer Project in late 1975.

I suppose I could suggest that this experience teaches everyone a lesson, but this is not true. The frightening fact is, that this lesson is evident, throughout this country, and is a growing factor in the economic problems that we all face. I have visions that things will not be better, but will only get worse as the bureaucracy to which we were subjected grows in direct proportion to its inability to comprehend the nature of its work.

Erv, forgive the length of this documentary - I hope it does someone some good, but I doubt it.

Respectfully yours,

Thomas J. McMahon, P. E.
President

TJM:it

cc to John Lambert

ATTACHMENT 6

THE IMPORTANCE OF WATERBORNE COMMODITY

MOVEMENTS THROUGH UPPER MISSISSIPPI RIVER PORTS

THE IMPORTANCE OF WATERBORNE COMMODITY
MOVEMENTS THROUGH UPPER MISSISSIPPI RIVER PORTS

by

Jerry E. Fruin and Richard Levins

The inland waterway system is a vital component of the transportation system of the Upper Midwest. Terminals in the greater Twin Cities area handle more than 15 million tons of waterborne cargo each year. Except for St. Louis, this is more than any other city on the Mississippi River above Baton Rouge, Louisiana. Total cargo handled by all river terminals in Minnesota and Wisconsin exceeds 20 million tons per year. The river system is especially important for the movement of bulk commodities like grains, agricultural products, fertilizers, chemicals, coal, and petroleum products.

Table 1 lists the commodities shipped from all 11 COE St. Paul District ports in 1975 in descending volume of shipments. Table 1 also indicates the quantity and percentage of each commodity that is shipped out of the District and the quantity and percentage of intra-District shipments to other ports within the St. Paul District. Table 2 is analogous to Table 1 but is for commodity receipts.

The volumes moved by water and the economic importance of the 10 highest volume commodities listed in Tables 1 and 2 are described in this paper. The discussion will for the most part emphasize the Twin Cities area, and data more recent than those used in Tables 1 and 2 will be used wherever such data are available.

Table 1 - Shipments of waterborne commodities from COE St. Paul District ports in 1975 (in short tons)

1975 volume rank	Commodity name	Shipments out of District	Intra-District shipments	Percen shipped out of District	Percent shipped in District	Total shipments	Percent of District total shipments
1	Corn	2,804,321	0	100.0	0	2,804,321	25.1
2	Coal and lignite	514,691	1,848,648	21.8	78.2	2,363,339	21.2
3	Wheat	2,014,109	17,645	99.1	0.9	2,031,754	18.2
4	Sand, gravel, rock	0	1,176,363	0	100.0	1,176,363	10.5
5	Gasoline	220,298	752,080	22.7	77.3	972,378	8.7
6	Soybeans	673,303	1,373	99.8	0.2	674,676	6.1
7	Processed agricultural products	396,490	532	99.9	0.1	397,022	3.6
8	Distillate fuel oil	91,499	244,978	27.2	72.8	336,477	3.0
9	Oats	145,066	0	100.0	0	145,066	1.3
10	Coke, pitch, asphalt	72,208	58,695	55.2	44.8	130,903	1.2
11	Residual fuel oil	30,505	4,076	88.2	11.8	34,581	0.3
12	Metallic ores	18,225	0	100.0	0	18,225	0.2
13	Barley and rye	8,266	3,886	68.0	32.0	12,152	0.1
14	Farm products	11,708	0	100.0		11,708	0.1
15	Waste/scrap metal	11,024	510	95.6	4.4	11,534	0.1
16	Potassic chemical fertilizers	10,045	0	100.0	0	10,045	(1)
17	Primary iron and steel	7,910	0	100.0	0	7,910	(1)
18	Jet fuel and kerosene	4,817	0	100.0	0	4,817	(1)
19	Building cement	2,857	0	100.0	0	2,857	(1)
20	Flour	2,299	0	100.0	0	2,299	(1)
21	Nitrogenous chemical fertilizer	1,250	0	100.0	0	1,250	(1)
22	Other fertilizer	0	912	0	100.0	912	(1)
23	Manufactured equipment and machinery	480	0	100.0	0	480	(1)
	Total	7,041,371	4,109,698	63.1	36.9	11,151,069	100.0

(1) Less than 0.1 percent. These eight commodities accounted for 0.3 percent of District shipments.

Table 2 - Receipts of waterborne commodities in the COE St. Paul District ports in 1975 (in short tons)

1975 volume rank	Commodity name	Receipts out of District	Intra-District receipts	Percent of receipts from out of District	Percent of intra-District receipts	Total receipts	Percent of District total receipts
1	Coal and lignite	2,987,616	1,848,648	61.8	38.2	4,836,264	50.0
2	Sand, gravel, rock	9,657	1,176,363	0.8	99.2	1,186,020	12.3
3	Gasoline	179,156	752,080	19.2	80.8	931,236	9.6
4	Salt	558,888	0	100.0	0	558,888	5.8
5	Distillate fuel oil	85,170	244,978	25.8	74.2	330,148	3.4
6	Other fertilizers	293,226	912	99.7	0.3	294,138	3.0
7	Chemical products	235,502	0	100.0	0	235,502	2.4
8	Coke, pitch, asphalt	136,838	58,695	70.0	30.0	195,533	2.0
9	Crude petroleum	195,294	0	100.0	0	195,294	2.0
10	Building cement	170,527	0	100.0	0	170,527	1.8
11	Nitrogenous chemical fertilizers	145,242	0	100.0	0	145,242	1.5
12	Primary iron and steel	126,817	0	100.0	0	126,817	1.3
13	Residual fuel oil	98,962	4,076	96.0	4.0	103,038	1.1
14	Phosphatic chemical fertilizers	95,192	0	100.0	0	95,192	1.0
15	Processed agricultural products	74,452	532	99.3	0.7	74,984	0.8
16	Jet fuel and kerosene	48,141	0	100.0	0	48,141	0.5
17	Organic industrial chemicals	35,067	0	100.0	0	35,067	0.4
18	Inorganic industrial chemicals	24,982	0	100.0	0	24,982	0.3
19	Wheat	1,650	17,645	8.6	91.4	19,295	0.2
20	Petroleum products	15,112	0	100.0	0	15,112	0.2
21	Pulp/paper products	9,403	0	100.0	0	9,403	(1)
22	Marine shells	8,532	0	100.0	0	8,532	(1)
23	Barley and rye	0	3,886	0	100.0	3,886	(1)
24	Limestone flux, calcareous stone	2,844	0	100.0	0	2,844	(1)
25	Phosphate rock	2,807	0	100.0	0	2,807	(1)
26	Flaxseed	2,805	0	100.0	0	2,805	(1)
27	Corn	2,800	0	100.0	0	2,800	(1)
28	Flour	2,623	0	100.0	0	2,623	(1)
29	Nonmetallic minerals	2,310	0	100.0	0	2,310	(1)
30	Waste/scrap metal	1,200	510	70.2	29.8	1,710	(1)
31	Soybeans	0	1,373	0	100.0	1,373	(1)
	Total	5,552,815	4,109,698	57.5	42.5	9,662,513	100.0

(1) Less than 0.1 percent. These 11 commodities accounted for 0.4 percent of District receipts.

Coal

Coal is among the most important commodities moved by water in the St. Paul District. In 1975, it ranked first in receipts and second in shipments. The economic advantages of these water shipments of coal is great - rail rates for coal were found to be substantially higher per ton-mile as those for barge in 1977. Typical barge rates were from $0.004 to $0.005 per ton-mile while unit train rates were from $0.008 to $0.015 per ton-mile.

Coal constituted 29.5 percent of the Twin Cities area barge shipments in 1976(1) with a combined total of 2,307,264 tons being shipped from the ports of Minneapolis, the Minnesota River, and St. Paul. This coal is virtually all received by train from western origins and transferred to barge in the Twin Cities. About 50 percent of the total goes to power plants on the Minnesota and St. Croix Rivers, and much of the remainder goes to other locations in the St. Paul COE District. No other pools in the St. Paul District shipped significant amounts of western coal in 1975.

Coal accounted for 41 percent of total barge receipts in the Twin Cities area in 1976. Other District pools that received significant quantities of coal were pools 5 and 8. In total, over 1.8 million tons of western coal was shipped by water between District terminals while nearly 3 million tons were received from midwestern sources on the river system at or beyond St. Louis, Missouri. The proportion of western coal is expected to increase in the future, although not as rapidly as from 1973 to 1976.(2)

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(1) The preliminary 1978 estimate is 2.2 million tons of coal shipped.

(2) The preliminary 1978 estimate is 1.8 million tons of western coal receipts and over 2.5 million tons of midwestern coal.

Farm Products

Farm products, especially corn, wheat, and soybeans, are the most important category of commodities shipped by water from the area served by the Upper Mississippi River. They are of vital importance to the region's economy and there is little doubt that structural changes would occur if low cost, reliable river transportation was not available to move a major portion of the marketable surpluses of corn, wheat, and soybeans to export ports.

Shipments of corn have historically accounted for the largest volume of shipments from Twin City terminals, although western coal shipments became larger than those of corn in 1975. In 1976, corn, wheat, soybeans, processed agricultural products, and oats ranked second through sixth in tonnage of water shipments from Minneapolis, St. Paul, and the Minnesota River. These five commodities accounted for 5,305,969 tons, or 67.8 percent of total shipments from the Twin Cities.(1) In addition, the general category farm products, which includes sunflower seeds and sorghum, ranked 8th, and barley and rye, ranked 12th, in volume in 1976.

For the entire St. Paul District, corn accounts for more shipments than any other commodity including coal. In 1975, corn, wheat, soybeans, processed agricultural products, oats, barley and rye and farm products ranked 1st, 3d, 6th, 7th, 8th, 12th, and 13th in tonnage shipped from the District and accounted for 54.5 percent of the total tonnage shipped from District ports.(2)

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(1) The 1978 shipments of grains and soybeans from the Twin Cities are estimated at 6.2 million tons. This does not include processed agricultural products.

(2) 1978 District shipments of grain and soybeans are estimated at 10.3 million tons.

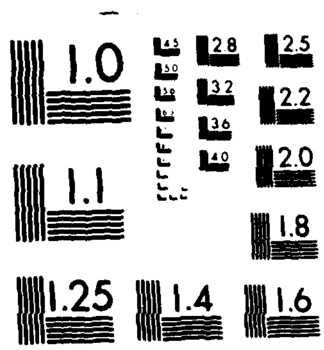
The economic importance of farm products barge shipments is best illustrated by considering those for corn, wheat, and soybeans (by far the most important crops) through Twin Cities ports. During 1970-1977, an average of 2.5 million tons per year (TPY) of corn was shipped from the Twin Cities. For comparison, the total production of corn in Minnesota, North Dakota, and South Dakota that was sold off-farm in that period averaged 8.3 million TPY. The 2.2 million TPY average for wheat shipments from Minneapolis compares to an average production of 11.2 million TPY in the tri-State region. For soybeans, average Minneapolis shipments were 748 thousand TPY; average tri-State production was 3.1 million TPY.

The ratio of barge-to-rail tonnage from Minneapolis during 1970-1977 has remained fairly constant at four-to-one. Barge shipments have averaged 4.44 million TPY; rail shipments have averaged 1.09 million TPY.

Consequences of All-Rail, No Barge Scenario

If for some reason the river was not available and all of the outbound Minneapolis shipments were by rail, the most important consequences would be those of higher transportation costs and strain on the rail system.

An average of 4.44 million tons per year of grain moved out of Minneapolis by barge during 1970-1977. If this was simply diverted to 75-car rail shipments, the transportation cost would increase by approximately $10 per ton, or $44.4 million per year. It is more likely that, without barge, other rail routes than those through Minneapolis to the Gulf would be used and shipments would be less than 75 cars. Any such scenario would involve substantially higher total costs to shippers as the recent 10 car rail export rates exceed barge costs by $18 a ton and single car rates are substantially higher.



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

The second implication concerns the ability of the United States rail system to handle such greatly increased grain shipments. In 1973, a year of severe rail car shortage, over 5 million tons of grain, the equivalent of over 50,000 jumbo hopper cars, left Minneapolis by barge. It would have been disastrous to attempt to put 5 million more tons onto the strained rail system in that year.

Assuming an optimistic 30 trips per year and an even flow throughout the year, an additional 1,500, 100-ton hopper cars would be needed to replace barges. This represents a capital investment of $80 to $100 million for cars and locomotives. How this would be financed is an important question. Furthermore, although the additional rail cars could probably be loaded at area elevators and terminals without difficulty, an additional 130 to 200 cars per day at export terminals would undoubtedly require substantial investment in holding tracks and unloading facilities if serious congestion is to be avoided.

Fertilizer

Water transportation is very important for the movement of nitrogen, phosphate, and mixed fertilizers to the Upper Midwest. Potassium fertilizer soucres are in Canada and move into this area by rail.

In 1975, nearly 25 percent of the direct application nitrogen fertilizer used in Minnesota was shipped by barge to terminals in Winona, pool 2, the Twin Cities, and the Minnesota River. The total transportation costs for direct application nitrogen are quite sensitive to distance from the river as truck costs increase rapidly. Costs of nitrogen fertilizer delivered to the farm by the barge-truck mode are up to $9 a ton less near the river than shipments by rail, but costs of direct rail shipments are only one-half that of barge-truck in the Red River Valley.

In 1975, quantities of superphosphate type fertilizers equal to 95 percent of Minnesota use were received at Winona, pool 2, the Twin Cities, and the Minnesota River. The least transportation cost method for these fertilizers is barge-rail throughout the State. Savings of \$9 to \$12 per ton over direct rail are normal. The barge-rail mode appears to be \$2.50 to \$4.00 a ton less than the barge-truck alternative. Unlike the rates for grain and many other commodities, rail rates for fertilizer in Minnesota are cheaper than truck at very short distances as well as at long distances.

The quantity of other mixed fertilizer received at Winona, pool 2, Minnesota River, and Twin Cities terminals in 1975 was 294,000 tons. This was equal to 38.8 percent of the mixed fertilizer used in Minnesota in that year. Rail rates for mixed fertilizer are generally slightly higher than for superphosphate while barge and truck costs are generally the same. Consequently, water transportation is used from manufacturing locations where it is available.

Petroleum and Petroleum Products

The general category of petroleum and petroleum products is second only to coal in tons of annual receipts by barge in the U.S. Army Corps of Engineers (COE), St. Paul District. Receipts of crude petroleum by barge, although negligible for years, jumped to 575,000 tons in 1976. Petroleum and petroleum products have typically accounted for the largest dollar value of annual commodity shipments on the inland waterway system. Some analysts have forecast major increases in petroleum movements by barge on the Upper Mississippi, although pipelines are generally considered the preferable transportation mode. The recent controversies over pipeline routes have demonstrated the value of the availability of water transportation for crude petroleum transportation into the Upper Mississippi River Valley.

Distillate fuel oil accounted for 2.9 percent of 1976 Twin City area receipts. A major portion (96.5 percent) is shipped from lower pool 2 to the Twin Cities terminals. Pools 6 and 8 received a total of 71,281 tons in 1975, 6.1 percent of which came from lower pool 2. 74.2 percent of total District receipts were from intra-District movements.

Twin Cities gasoline receipts by barge accounted for 11.4 percent of Twin City area receipts in 1976. In 1975, 89.2 percent of the gasoline receipts originated in lower pool 2 below mile 830. Other District pools received 113,211 tons of gasoline in 1975 with most of it going to pools 6 and 8. 80.8 percent of the gasoline received at all District ports was from intra-District movements.

In the past, crude petroleum moved into Minnesota almost entirely via pipeline. While the pipelines accounted for 7.1 million tons in 1975. barge traffic carried a total of only 195,294 tons (table 2) into the COE St. Paul District. The eight Class 1 railroads that operate in the State reported only 26,560 tons of crude petroleum moved into the State by rail in 1975. These figures then show that 2 percent of crude petroleum brought into Minnesota moved by barge and less than 1 percent by rail. However, receipts of crude petroleum by barge, although negligible for years, jumped to 575,000 tons in 1976.

Actual rates are not regulated for barge movements of petroleum products as they are in pipelines and rail and can vary because of costs or market conditions. The 1975 rate for movements between Minneapolis/St. Paul and the Gulf ranged from $7.12 to $9.49 per ton according to one source. This is for a distance of approximately 1,800 miles and $0.0040 to $0.0053 per ton-mile. One alternative mode, that of a pipeline, has a rate of $6.98 per ton or $0.0039 per ton-mile. This is an actual tariff rate. The other possible alternative, rail, could be as high as $19.80 per ton or $1.15 per ton-mile. This is the estimated cost for the Burlington Northern/GATX proposal for unit train deliveries of Alaskan crude oil from Oregon to Minneapolis/St. Paul. It is approximately the same distance as from the Gulf but might be based on higher costs because of the mountain ranges that must be crossed to bring the oil from the West Coast.

Pipelines presently carry over 90 percent of the crude oil supply to the four Minnesota refineries and also the major share of the petroleum products. The pipeline offers a cheap, efficient mode for transporting liquids. It normally offers a constant flow of products yearlong which cuts down the demand of storage facilities at the end point. Pipelines also allow the shipper to mix shipments of different products which are separated at the destination. A number of proposals for new pipelines are in the hearing stage, but face opposition from environmentalists and farmers. Until these pipeline proposals reach a final decision, barges could be expected to pick up some of the increased demand for petroleum and its products.

Other Large Volume Commodities

Sand, gravel, and rock account for 24.5 percent of Twin City area receipts (1.2 million tons in 1975). Nearly all of the sand, rock, and gravel received in Minneapolis and St. Paul are shipped from lower pool 2, a very short haul of 10 to 30 miles. These shipments have not been included in compilations of Twin Cities area shipments, although they have always been counted as receipts. Although transportation cost advantages are not great because of the short distances, this is the equivalent of 55,000 truckloads per year. Highway maintenance and congestion are reduced substantially by this movement.

Shipments of coke, pitch, and asphalt from the Twin Cities have increased at a compound annual rate of almost 34 percent over the 14-year period ending in 1976 although down from the high levels of 1971 and 1972. Over 53,000 tons of this commodity was also shipped from pool 2 below mile 830 in 1975. Most of the shipments in this category are of petroleum coke and are destined for area electric generating plants.

Receipts of this category in the Twin Cities are primarily of materials such as asphalts and tars rather than coke or petroleum coke and amounted to 78,000 tons in 1975. The growth rate over the 14-year period was 0.8 percent per year although there were several years in the middle of the period when reduced quantities were received. Pools 5 and 9 received 58,695 tons of petroleum coke for boiler fuel. All of the petroleum coke received at these two locations was an intra-District shipment from lower pool 2.

In 1975, salt constituted 5.8 percent of total barge receipts in the District (560,000 tons). During the last 10 years, receipts in the Twin Cities have grown at an average annual rate of 6.1 percent. Other pools which received significant quantities of salt in 1975 were pools 4, 6, 8, and 10. These pools received a total of 138,383 tons in 1975 or 24.8 percent of the COE St. Paul District total. This is a long distance bulk commodity movement and consequently provides major economic benefits to the region. In 1975, rates for hauling salt from Louisiana to Minnesota were estimated at $5.45 per ton by barge and $15.47 per ton by rail.

The chemical products category ranked seventh in terms of total COE St. Paul District receipts in 1975, accounting for 2.4 percent of total District receipts. Virtually all of the chemical products were received in pool 2 below mile 830.0 and originated outside of the St. Paul District. Rates for rail movements typically are two to four times the rate for water movement.

Building cement comprised 1.8 percent of the St. Paul District's barge receipts. In 1975, there were 75,772 tons of cement shipped into pool 8 so that "other" District ports account for 44.4 percent of total District receipts of cement. A 1975 study indicated that rail rates typically were three times those of barge rates for cement.

Trends and Implications

Barge shipments have been increasing at a faster rate than barge receipts in the St. Paul District for at least 15 years. Although part of the increase in shipments in recent years has been due to the shift to western coal which is primarily a local movement, long distance shipments of corn and wheat are expected to continue to increase. One study projected that total St. Paul District shipments would be 59 percent greater in 1985 than in 1975 with most of the increase due to farm products. The same study indicated that receipts would be relatively constant over that time period.

The physical capacity of the river channel itself greatly exceeds this or any other projection of future bulk commodity transportation requirements. However, there are possible physical and operational constraints that could limit future growth or even reduce waterborne commerce. Such possible constraints include insufficient terminal capacity to load and off-load cargo, inadequate fleeting areas for combining the individual barges into tows and breaking tows down to individual barges and for the storage of empty and loaded barges, the capacity and operational readiness at each of the 29 locks and dams on the Mississippi River between Minneapolis and St. Louis, and the depth and width of the river channel where maintenance dredging is required. Inadequate expansion, deterioration, or catastrophic failure in any of these areas would have detrimental effects on water transportation. These effects could range from causing incremental cost increases and small reductions in the volume shipped by water to eliminating long distance water movements with major increases in transportation costs to area shippers and consumers.

Public policy decisions are required to ensure that these factors do not constrain waterborne commerce. Some of the decisions affecting capacity are primarily of a local nature such as whether to allow the expansion of a given terminal; others such as the regulations restricting the Corps of Engineers channel maintenance dredging may be State decisions, and some such as whether to rebuild or replace lock and dam 26 near Alton, Illinois, are national issues. These issues have generated controversy in the past and surely will in the future. Minnesotans and other Upper Midwest citizens, both shippers and consumers, should recognize the importance of the inland waterways to their region's economy and ensure that the benefits of water transportation are fully considered when public policies are determined.

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